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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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Full particulars of plant together with tender form and permits to view may be obtained on application to the CONTROLLER, D.B.1.(E), Charing Cross Embankment Huts, London, S.W. 1.

All Tenders to be received by TEN a.m., August 6th.

NOTE.—For particulars of other Government Property for Sale, see *Surplus*, price 3d. at all Bookstalls; or by quarterly subscription of 2s. post free in the United Kingdom, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. H 913

PORT OF BRISTOL.

EXTENSION OF GRANARY,
ROYAL EDWARD DOCK, AVONMOUTH.

The Docks Committee are prepared to receive

Tenders for the Construction

of a FERRO-CONCRETE BUILT SILO GRANARY of 20,000 tons capacity, carried on Ferro-concrete Piles.

On and after Wednesday, the 4th August, 1920, copies of the Specification and Contract Drawings can be obtained from the undersigned on production of a receipt shewing a deposit of £5 has been paid to the SECRETARY of the Docks Committee, at 19, Queen Square, Bristol, to whom all cheques must be made payable. The deposit of £5 will be returned to all bona fide Tenderers after the receipt of a Tender with all the prescribed documents and drawings.

Tenders must be enclosed in a sealed envelope, endorsed "Tender for Extension of Granary," and addressed to the SECRETARY of the Docks Committee, 19, Queen Square, Bristol, and must be delivered to him accompanied by all the prescribed documents and drawings before Ten a.m., on Friday, the 27th August, 1920. The Docks Committee do not bind themselves to accept the lowest or any Tender.

THOMAS A. PEACH,
Engineer's Office, Engineer.
Avonmouth Dock.
17th July, 1920. H 885

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the

following STORES, namely:—

	Specification Fees.
1. Wicks, Lubricating Pads, &c.	10/-
2. Paints, Drysalteries, &c.	10/-
3. Platelayers' Tools.	10/-
4. Lamps and Fittings.	7/6
5. Acid Open Hearth Steel Boiler Plates.	5/-

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned. The fee should accompany any application by post.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Wicks, Lubricating Pads, &c.," or, as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 10th August, 1920.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE,
Secretary.

Company's Offices,
48, Gepthall Avenue, H.C. 2.
London, 21st July, 1920. H 907

BURMA RAILWAYS COMPANY, LIMITED.

The Board of Directors of the Burma Railways Company, Limited, are prepared to receive

Tenders for the Supply of

BRIDGEWORK (3-100 ft. Spans).

For each copy of the specification a fee of 20/- will be charged, which fee is not returnable. Tenders enclosed in sealed envelopes addressed to the "Chairman and Directors" and endorsed "Tender for Bridgework" must be delivered at the Company's Offices not later than Twelve noon on Friday, 13th August, 1920. The Directors do not bind themselves to accept any or the lowest Tender, and reserve the right to divide the order.

The Spans are very urgently required in Burma.

By Order of the Board,
W. HOME,
Managing Director.

199, Gresham House,
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London, E.C. 2.
22nd July, 1920. H 903

SWANSEA HARBOUR TRUST.

STEEL RAILS AND FISHPLATES.

The Trustees invite

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DELIVERY, f.o.r. Prince of Wales Dock, Swansea, of the following:—

About 200 tons of 80 lbs. BULL-HEAD SECTION RAILS.

About eight tons of SHALLOW FISHPLATES to match.

About 140 tons of 80 lbs. FLAT-BOTTOMED SECTION.

About six tons of SHALLOW FISHPLATES to match.

The Rails and Fishplates to be in strict accordance with the British Standard Specifications.

Further particulars and Forms of Tender may be obtained at the Harbour Offices, from Mr. A. O. Schenk, the Trustees' Engineer.

Tenders sealed and marked "Rails and Fishplates," should be delivered to the undersigned on or before Wednesday, 4th August, 1920.

The Trustees do not bind themselves to accept the lowest or any Tender.

TALFOURD STRICK,
(Clerk).

Harbour Offices, Swansea.
12th July, 1920. H 779

G. R.

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All Tenders to be received by TEN a.m., August 6th.

NOTE.—For particulars of other Government Property for Sale, see *Surplus*, price 3d. at all Bookstalls, or by quarterly subscription of 2s. post free in the United Kingdom, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. H 912

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Timber-framed, match boarded inside, wood-floors, well-lighted, excellent condition.

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TWO LECTURERS in Engineering Subjects.
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AUSTIN MOTOR CO., LTD., BIRMINGHAM.

Applications are Invited for

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There will be a Vacancy in

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Preference will be given to those candidates who have served, or attempted to serve, with the forces of the Crown.

Application forms may be obtained from the Education Officer, (T.1(a)), Education Offices, Victoria Embankment, W.C. 2 (stamped addressed foolscap envelope necessary). Form must be returned by 11 a.m. on 29th July, 1920. Canvassing disqualifies.

JAMES BIRD,
Clerk of the London County Council.
H 935

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THE INSTITUTION OF NAVAL ARCHITECTS.

(*Concluded from page* 87.)

INTERNAL-COMBUSTION MARINE ENGINES.

ON Thursday, the 8th inst., the technical proceedings of the Institution were continued, a meeting being held at 10 a.m. in the Lecture Hall of the Central Technical School, under the chairmanship of the president.

Two papers on allied subjects were first taken together for reading and discussion. These were "Some Experimental Work in Connection with Diesel Engines," by Engineer-Commander C. J. Hawkes (retired), and "Comparative Trials of 'Still' and 'Sulzer' Engines under Actual Working Conditions on Board Ships," by Mr. William Denny. In both cases the papers were read by their authors. Mr. Denny's paper will be found reprinted on page 98 of last week's issue. Engineer-Commander Hawkes' paper will be found on page 127. It is concerned with a record in some detail of experimental work carried out with Diesel engines at the Admiralty Engineering Laboratory. The author was congratulated by several speakers on becoming Engineering Professor at the Armstrong College, Newcastle-on-Tyne.

Sir George Goodwin opened the discussion. He said he supposed it would come as a surprise to some people to hear that the Admiralty had an engineering laboratory. It owed its existence to the Board of Invention and Research. Such a laboratory had long been under consideration, but there had never been funds available for its equipment. He had had many disappointments in connection with the matter and was very glad when the laboratory was finally established. In the old days it had been necessary for the Admiralty to depend on private works for preliminary experiment. It had often been felt that this was hardly fair, and at the present time he supposed it would be hardly possible. Their business in their new laboratory was, of course, concerned with naval problems, but much of their work would doubtless be useful in the merchant service, and now that they had permission they hoped to publish more information in the future. An efficient head was most important in any laboratory, and they had been most fortunate in having Commander Hawkes, but he had now left them.

Sir George went on to say that he did not desire to comment on the details of the paper, but he might say that soon after the laboratory was started they began to get information from the Navy about difficulties and were able to help in many ways. In connection with aluminium pistons he might say that a set was fitted on a submarine, which, after 300 hours' running, were taken out and sent to the National Physical Laboratory, where they were reported on to be in an absolutely satisfactory condition. After this aluminium pistons were fitted to the whole of one class of submarines. This was two years ago, and the pistons were still all right. This had enabled the power of the boats to be increased. This change had been made possible by the work of the laboratory. It was stated in the paper that there was no growth of the aluminium alloy, but he might say that since it was written evidence was available of a slight growth going on. He would like to emphasise the reference in the paper to the necessity for co-operation between engineers and metallurgists. He sometimes thought that in some directions the engineer was now ahead, and the statement that they should be working together under one roof was very sound.

Professor W. H. Watkinson said that the subject of the internal-combustion engine for the propulsion of ships was of primary importance. Many believed that ultimately it might become the only agent of such propulsion. He much appreciated the good work of the Admiralty Laboratory, and pointed out that Commander Hawkes' paper should be looked upon as of a preliminary nature only. The question of detonation, for instance, was touched on, but not fully. This matter was one of great importance and on it little was known. He hoped they might later have another paper dealing with the matter fully. On the question of co-operation between the metallurgist and the engineer he would point out that the two were closely allied at the Liverpool University and that Messrs. Alfred Holt and Co. had founded a chair of metallurgy in the Faculty of Engineering. In connection with the reference to a compound internal-combustion engine in the paper he would like further details about what had been done. As the compound engine had supplanted the single engine in steam work, so he thought in the future we would come to the use of compounding in internal-combustion work. Mechanical complications were probably not inherent in such compound internal-combustion engines.

Turning to Mr. Denny's paper Professor Watkinson pointed out that it was an excellent example of a paper devoted to facts and not to opinions, and some of the facts given were most important. He would point out that the mechanical efficiency of the engines was very low, down to something like 0·67 or 0·69. The thermal efficiency saved the situation, but the mechanical efficiency was much lower than it should be. Neither engine, he noted, had a fuel consumption of less than 0·44 lb. per shaft horse-power per hour. This was disappointing for the Still engine since a figure of 0·4 had been obtained with no special arrangements. He noted that the consumption curve of the Still engine curved upwards at the end. This he attributed to bad combustion and thought air injection would improve matters. Professor Watkinson went on to say that twenty-two years ago he had tested the first Diesel engine built in this country. The total consumption curve was found to turn up just like the curve for the Still engine in the paper. He thought at that time that this was due to imperfect combustion and the idea was confirmed by an examination of the exhaust. He would like to know why the vacuum of the Still engine was so wretchedly bad, only about 9 lb. and also why the maximum steam pressure was not more than 25 lb. Surely these figures might be improved on if good results were wanted. He would also like to ask why the engine was designed to run astern on steam only, had this anything to do with the angular spacing of the cranks?

Mr. James Richardson said that it must be agreed that the paper of Commander Hawkes was very pleasant reading since the large Admiralty experimental engine was conceived, designed and constructed before particulars were available of the German 20·8 in. diameter cylinder submarine Diesel engines. Especially pleasing were the results of the experiments in view of the very considerable publicity given to the details and performance of these German engines in the technical press. The results given by Commander Hawkes showed that there was no mystery about the performance of the German engines and that results equally good could be achieved without encountering any outstanding difficulty. It should, however, in fairness be noted that the engine described by Commander Hawkes was a single-cylinder unit running in a laboratory, whereas the German engine was a multi-cylindered machine actually in operation in submarines at sea. It should, however, also be put on record that the results of the trials at the Admiralty laboratory indicated a degree of efficiency of Diesel engine performance higher than had ever before been achieved. This was a very substantial success of which all concerned might well be proud.

Interesting comparisons arose from the results of the trials, and it would be seen that with the smaller engine of 14½ in. diameter, powers of over 100 lb. per square inch mean effective pressure on an indicated horse power basis could not be obtained without smoky exhaust and this on a fuel oil such as shale oil of 0·86 specific gravity; whereas with air injection on the larger engines and Texas oil of 0·92 density, 130 lb. per square inch and even more was maintained with an excellent fuel consumption per brake horse-power per hour. Supercharging with the smaller engine increased the mean effective pressure without however clearing the exhaust and the consumption of fuel oil was still unsatisfactorily high. Air injection could, of course, be regarded, as compared with solid injection, as supercharging, since the air introduced to spray the fuel oil into the cylinder assisted and supported combustion of increased quantities of fuel oil. It was to be noted that experiments would in due course be carried out with supercharging on this larger cylinder 20 in. in diameter in conjunction with air injection of the fuel.

Mr. Richardson went on to say that in his opinion it would be a matter of considerable difficulty to effect supercharging with an air injection engine and to show an overall gain. Ports in the bottom of the liner were suggested as a means of introducing the extra air. He considered that every other method of introducing the supercharging air should be explored before the ports were resorted to. The introduction of such ports with the air belt would tend to rob the four-cycle engine of some of the structural simplicity that gave it much of its advantage as a marine prime mover. Taking the results, however, as they stood, he agreed with Sir George Goodwin that they would serve a considerable purpose in connection with marine work. The path of progress with the standard mercantile engine that lay immediately to hand was to reduce its weight, its clumsiness and the space occupied. With certain types of vessel the naval architect would find that the oil engine could not well be applied on account of these factors. Such improvement could only be effected by increasing piston speeds and mean effective pressures and these were two questions with which Commander Hawkes's paper primarily dealt. There was one point of criticism which might be raised. The fuel consumptions for the two engines and the various trials had been measured with very accurate apparatus and were stated to two places of decimals. The actual tested calorific values of the two types of fuel used were not however given. Whilst it would not be expected that the values could differ much the one from the other, yet a small difference would alter the fuel consumption figures. For a true comparison calorific values must be taken into account.

Mr. Denny's paper comparing the Still and Sulzer installations in regard to their actual performance at sea was also a record of facts. Judging from the plans of the machinery on board, the impression certainly was obtained that the Still engine with its combined oil and steam plant was much the more complicated. An important point was that with such an installation the requirements of the classification societies in regard to safety and security of operation had to be observed in full both for the oil and also for the steam installation. The curves of performance would be improved and a better conception, at a glance, of the relative efficiencies would be obtained if mean effective pressures in the working cylinder were also plotted on a basis of revolutions per minute. There could be no doubt, as mentioned by Professor Watkinson, that the combustion of the Still engine broke down at, or about, 240 revolutions per minute. The curves of consumption of fuel oil showed the same remarkable and unexpected break-down. This was exactly the opposite of what would be expected. It would be estimated that only when the mean effective pressure in the oil cylinder reached a substantial figure would sufficient steam be generated in the jackets and by the exhaust to have any appreciable influence on the overall economy.

Mr. Le Mesurier said he had been struck by the difference in rating of the Sulzer and Still engines. The Sulzer dimensions seemed considerably in excess of what was required. The maximum load of the Still engine was given at 240 r.p.m., but they also happened to be the speed corresponding to the normal speed of the ship. The shaft horse-power of the Sulzer engine at this speed was, however, given with a mean effective pressure of 58 lb., which was considerably below the full power of the engine. The comparison was thus unfair to the Sulzer engine. For best results the Sulzer engine should have had 8-in. cylinders, which would have given better results and full margin for overload. The total effect would have been a saving in weight, a saving in space and a saving in fuel consumption, since the engine would have worked nearer full load conditions. No doubt the engine actually used was selected as the nearest standard available, but the effects he had pointed out were important.

In connection with the typical indication diagrams given in the paper, he noted that Mr. Denny,

referring to the Still engine, said "the compression pressure in the cylinder is considerably lower than in the case of ordinary Diesel engine practice." This might be so, but the diagrams did not indicate any great difference in the conditions in the cylinder between the Still and Sulzer engines. In connection with the curves of indicated horse-power he suggested that the errors which inseparably came in in such measurements might modify the curves considerably. Similarly in connection with the low mechanical efficiency which Professor Watkinson had mentioned, he did not think the figures could be quite accurate for such small engines as those dealt with and in any case they cover pump friction, &c. The curves given in Fig. 4 of the paper were the least liable to error and of the greatest practical importance. It would be seen that at about 242 r.p.m., which was the service speed, the oil consumption of the Still and Sulzer engines was equal, and this was despite the fact that the Sulzer engines were of a 1913 model and that the cylinder dimensions were not appropriate for purposes of comparison. Fig. 4 showed clearly that with a slight alteration in the cylinder dimensions the Sulzer engine would have better fuel economy than the Still engine.

He noted that the boiler which worked in conjunction with the Still engine had been free from trouble with oil. This was important, and was contrary to what most engineers would have expected. A piston rod alternately entering the closed crank chamber and the cylinder of oil engine driven dynamos in ship work had given much trouble. The Still engine had apparently been free from difficulties in connection with this matter, although he noted that Mr. Denny said the filters required very frequent attention. With more prolonged running he doubted if one would avoid contamination. Mr. Le Mesurier concluded by saying that he had not had the benefit of seeing Commander Hawkes' paper before coming to the meeting, and hence was hardly prepared to discuss it. There was one point, however, which he might mention. This was in connection with the use of high mean effective pressure in the cylinders of naval engines. In this matter he did not think any difference could be drawn between naval and mercantile engines. The question of piston speeds was another matter, however.

Mr. Shannon, referring to the first paper read, said that in his opinion the limit to supercharging would be found in the crankshaft, especially with eight-cylinder engines. Supercharging might increase the output by as much as 50 per cent., but the crankshaft would prove a serious problem. He thought the paper threw valuable light on the question of solid and air injection, and agreed with Mr. Richardson that oxygen in the air blast would increase the pressure. In connection with matters of rating he would point out that the merchant service wanted stayers and the Navy wanted sprinters. The best rating for the merchant service was the rating of lowest fuel consumption. An engine which got an increased output of 4 per cent. to 5 per cent. at an increased fuel consumption of 7½ per cent. was no good for the merchant service. In the matter of detonation he would say that they obtained it under some conditions with the Cammell-laird-Fullagar oil engine, but could not find that it was associated with any increase in pressure. They were able to control it in the same way as was indicated in the paper. Finally he would say that he would like to have the opposed-piston engine added to Table VI of the paper.

Mr. Leigh Martineau said that at the moment he wished only to say a very few words. In the first place he wished to point out that the Still engine dealt with in Mr. Denny's paper was the first of its type designed, and put on a boat for using fuel oil, whereas the Sulzer engine with which it was compared had ten years' sea experience behind it. The second point was that no great effort was made in the design of the Still engine to reduce weight, as the reduction was in any case so great as compared with a steam engine. There was no doubt but that further reduction could have been made had it been desired. He would also like to refer to the question of manœuvring and to point out that Mr. Denny admitted that the Still engine was superior in this respect. His last point was that if compounding had been used on the steam side the full value of the high boiler pressure could have been utilised instead of the steam having to be throttled down as was done. As it was, the Still engine, using solid injection, showed a saving of 2½ per cent. to 5½ per cent. in fuel.

Mr. Martin said the papers showed much useful work was being done in connection with the development of marine oil engines. In connection with the idea underlying the Still engine he would point out if the exhaust from a Diesel engine was used to heat air, this air could be used for driving the steering gear engine.

Mr. Scholes, the last speaker in the discussion, said that Commander Hawkes' paper was full of valuable suggestions. He had been interested to note that naval people were following the lead of aircraft engine designers in employing aluminium pistons. Such pistons were, of course, valuable in aero engines in helping to reduce high-speed inertia stresses, while in car work their heat-conducting properties were useful. He would like to know if it was for similar reasons that such aluminium pistons were being used in naval engines, or, if not, what was the idea of using them at all. Aluminium had been entirely satisfactory for small pistons, and he would be interested to know how it ultimately behaved for sizes up to 20 in. diameter. He would like to know if any attempt had been made to plot a heat balance and show the effect of the aluminium pistons.

Engineer-Commander Hawkes then replied to the discussion. He thanked Sir George Goodwin for his remarks and said that much of the success of the work done had been due to his encouragement. In connection with Mr. Richardson's remarks on supercharging he would say that his idea was to put the extra air in at low pressure and not through the fuel valve. He did not think there would be any objection to ports through the liner, as they would only have to pass cool air. The calorific value of the fuel which was asked about was 18,400 British thermal units. There was no trouble with gumming up in the engine, although it had run for many times more than 30 hours, and combustion was not quite complete. He appreciated Mr. Shannon's point about the crankshaft, but did not think it would limit development in the direction he had indicated. He thought the better results obtained with air injection were due to a better distribution of the fuel. In connection with high mean pressures, he would say that he did not recommend them for merchant service engines. Mr. Shannon had referred to Table VI, and said he would like the figures for the Camm llaird-Fullagar engine added to it. These would come out at 1·55 for an eight-cylinder engine and 1·01 for a twelve-cylinder engine. This showed the desirability of not having a large number of cylinders with the Cammellaird-Fullagar engine.

In connection with Mr. Martin's scheme for driving the steering engine by air heated from the exhaust of a Diesel engine, he would say that he did not think the scheme would be satisfactory on board ship. The air would lose much of its heat if it had to be carried far. Some work had been done in the matter in the dockyards. Replying to Mr. Scholes's question about aluminium pistons Commander Hawke said that essentially they had tried aluminium pistons just to try them and see how they would do. He did not think they had any definite preconceived ideas. There was no doubt but that one effect of such pistons was that the cylinder liner remained in very good condition. Even a seizure did not spoil the liner. A heat balance had been taken out, but he did not remember the exact figures. Speaking from memory, about 11 per cent. of the heat went through the jackets. Referring to Mr. Denny's paper, Commander Hawke mentioned the rise in consumption with the rise in indicated horse-power. The horse-power figures, of course, included the steam end, but from the point of view of consumption it was only necessary to consider the oil side. He thought the rise in consumption was due to delayed combustion as a result of running with too high a piston temperature. The matter turned on the ability of the engine to produce sufficient steam to cool the piston properly. He thought the engine was not doing this and that the piston got too hot.

Mr. William Denny also replied to the discussion. In reply to Professor Wilkinson's question about the low vacuum he said that this was due to the air pump being too small. An increase in vacuum would, however, only have given a slight increase in the steam power which was only 10 per cent. of the total. Professor Watkinson had also asked why the engine was designed to run astern on steam only. He would say that the engine was the first of its type, and as no Still engine had previously been run astern it was decided to keep to the crank angles with which most experience was available. The power of the Sulzer engine, compared with that of the Still, was as 100 to 80, but the Sulzer had, of course, to drive the compressor. The reason the 8½-in. cylinder Sulzer engine was used was that when designs were asked for from Messrs. Sulzer they sent the 8½-in. cylinder engine as the nearest stock size. The Still engine worked at a lower compression. He did not think the trials dealt with were of sufficient duration to determine relative reliabilities. In connection with Mr. Le Mesurier's remarks about contamination of the boiler in the Still installation he would say that there was a separator below the engine exhaust and that the water passed through filters filled with towelling. This towelling certainly got rather dirty and had to be attended to fairly frequently. In respect to Mr. Martineau's remarks about manœuvring the Still engine was certainly quicker when the steam end was in operation.

The Efficiency of Propulsion of Ships.

The President at this stage vacated the chair, and his place was taken by Sir Archibald Denny. The next paper taken was the last on the programme of the meeting. It was entitled "The Efficiency of Propulsion of Full-Sized Ships," and was read in abstract by the author, Mr. C. Frodsham Holt.

The paper, which we hope to reprint later, began by pointing out that although data was available, in the works of Mr. R. E. Froude and Admiral Taylor, on the performance of model propellers to cover the whole field of ordinary ship design, with the exception of the fastest types of destroyers and cruisers, it was not possible to use these data directly in design because of the differences existing between the behaviour of a model propeller working in open water and a full-sized propeller working in the disturbed wake behind a ship. A step forward had been recently taken when the actual thrust of each propeller of the H.M.S. Mackay was accurately measured and recorded for a wide range of speed and power. This boat, a flotilla leader of the Scott class, was built by Messrs. Cammell Laird. The only other published results of which the author had knowledge were those carried out on the t.s.s. Oyapock, built by the same firm thirteen years ago. Details of the experiments were communicated to the Transactions of the Institution by Mr. Hamilton Gibson. The author had analysed these trials and had been able to assess the values of the several elements of the efficiency of propulsion and thus compare the performance of full-sized propellers with that of models. The basis of the analysis was that which Mr. R. E. Froude presented to the Institution in 1908 for estimating the thrust horse power of model propellers. This basis was substantially confirmed by Professor T. B. Abell in 1910, who compared it with Mr. D. W. Taylor's experiments on slightly larger propellers. The method of analysis consisted essentially in plotting curves of thrust horse-power, thrust and model propeller efficiency on a basis of real slip ratio, using values deduced from Mr. Froude's propeller experiments. With the trial data available the problem could be approached either by working from a point on the diagram where the thrust was equal to that observed on the ship, or from the propulsive coefficient based on an estimate of effective horse-power and shaft horse-power actually observed.

Mr. Hamilton Gibson opened the discussion. He said that in an early part of the paper reference was made to the propeller thrust measurements which were carried out on the t.s.s. Oyapock and H.M.S. Mackay. Some time before 1907 he had obtained a record of the horse-power of a marine turbine by measuring the torque in the propeller shaft, and it had occurred to him later that if a record of the actual push of the propeller

on the shaft could be obtained a direct comparison might be instituted between the power transmitted to, and the thrust produced by, the propeller. A first experiment was made on a small triple expansion reciprocating set, by fitting spring balances to the thrust and gradually slackening the thrust rings away from their solid attachment. The oscillation of the pointers of the balances, however, made it impossible to obtain any reliable reading. Mr. Purves, one of his assistants, then suggested that it might be possible to get results if an hydraulic cylinder were introduced to take the thrust and the pressure produced was measured on an ordinary gauge. The details were worked out by Mr. Purves, and powers up to 700 h.p. were successfully measured on a reciprocating set on a small boat.

The gear was not applicable to a direct-driven marine turbine, but with geared turbines there was no difficulty, and the coming of the Michell thrust block had made the application a very simple one. The arrangements used with a Michell block were described in his Institution paper of last year.* In addition to the Mackay referred to in Mr. Holt's paper he would say that the Pacific boat Oropesa had been fitted. He thought this procedure might profitably be followed in at least one vessel of each important class built. This appliance appeared to have brought us to the stage at which the naval architect could say that he wanted machinery for a propeller to give so many tons thrust. In conclusion, he should express his appreciation of the generous and enlightened policy of his firm, Messrs. Cammell Laird, in allowing this work to be carried out. There was always some element of risk in playing about with hundreds or thousands of horse-power.

Professor T. B. Abell, the next speaker, said that Mr. Holt had gone a step further forward in attempting to measure another element among those needed in the determination of the details of a screw-propeller. The chief elements involved were the revolutions per minute, the speed of the wake, the thrust, and the thrust deduction. Among these we still did not know the speed of the wake and the thrust deduction. There was, however, another unknown element, and that was the pitch of the propeller. We did not know what the pitch of a propeller actually was, but Mr. Holt had used it as a known element in his calculation. In this Professor Abell thought he was not justified. He had based his work on Mr. Froude's paper of 1908, but Professor Abell thought he had misapplied the data of that paper. He had personally had an opportunity of going through all the work of the 1908 paper with Mr. Froude, and could say that that paper was not to be understood as Mr. Holt had understood it. The essential point was the factor 1·02 by which the face pitch was multiplied to give the effective pitch. This 1·02 really included all appendage resistances, but Mr. Holt used it directly in his calculations. In this Professor Abell thought he was quite wrong. His general method was admirable, but his thrust h.p. was calculated on a wrong basis, and Professor Abell would like him to reconsider the matter in the light of this criticism.

Mr. A. T. Wall said that naval architects looked forward to the thrust measurement trials on which the paper was based, and he thought Mr. Holt was to be congratulated on his contribution. It was well known that there were differences between model and full-scale experiments, and that the propeller coefficient varied even for similar ships with different propellers. Mr. Holt's paper marked a new phase in the investigation of the matter; and the point which stood out was that he had found a propeller doing only 85 per cent. of the work which would have been expected from model experiments.

Sir Archibald Denny said that they had been doing a large amount of experimental work with propellers behind models in his firm's experimental tank, and had had a large measure of success. The coefficient which they had found did not greatly differ from unity. They were of opinion that the true pitch of a propeller varied with the power it was transmitting. With a fine pitch the real pitch was greater than the apparent pitch.

* See ENGINEERING, vol. cvii, page 765.

Mr. Frodsham Holt then replied to the discussion. He said that Professor Abell had mentioned to him before the paper was read that he did not agree with his interpretation of Mr. Froude's work, but even after that, and after what Professor Abell had said in the discussion, he was still convinced that his understanding of Mr. Froude was correct. He would point out that Mr. Baker used the same reading as he did, and that as recently as the previous week the Schiffbautechnische Gesellschaft used the same interpretation.

This concluded the technical proceedings of the meeting, and the chairman proposed votes of thanks to the Lord Mayor of Liverpool, the Reception Committee and the various authorities and firms who had treated the Institution with such consideration and kindness during its visit.

VISITS AND EXCURSIONS.

On the afternoon of Thursday, the 8th inst., the members of the Institution were taken an excursion on the River Mersey on the Mersey Dock Board steamer Galatea and the Cunard tender Skirmisher. The party disembarked at the Gladstone Dock for an inspection of the Aquitania, where they were entertained to tea by the Cunard Company. Alternative visits were available to Messrs. Johnson Brothers' dye-works and Messrs. J. Bibby and Sons' seed-crushing mills.

On Friday, the 9th inst., the last day of the meeting, a visit was paid to Messrs. Vickers' works at Barrow-in-Furness. A special train was provided from Liverpool. The time available was insufficient for an examination of all the features of the Barrow establishment, and the party was divided into groups, some viewing the airship shops on Walney Island, and others visiting the shipbuilding and engineering departments. Messrs. Vickers entertained the members of the Institution to lunch immediately after their arrival. Sir James McKechnie presided, and welcomed the visitors. He said that the occasion was the first time in the history of the Institution of Naval Architects that it had visited Barrow, but he trusted it would not be the last. Sir John Biles, in replying, mentioned that during the war the Barrow works had produced 64 warships of various types. It was particularly in connection with submarines that the naval shipbuilding side of Barrow was famous, and for many years such craft were never built elsewhere in this country.

This Barrow visit formed a pleasing termination to what certainly was one of the most successful summer meetings ever held by the Institution of Naval Architects.

THE STATUTE OF MONOPOLIES.

IN the time of James I matters had come to such a state with regard to monopolies granted by the Crown, that in 1623 the above Statute was passed declaring such monopolies illegal with the exception of Letters Patent for inventions. These were to cover new manufactures which others at the time of making the grant of Letters Patent were not using, provided that the grant were not in restraint of trade and so on. This statute, therefore, did not create any monopoly but, practically, put the matter of monopolies on a definite basis.

The statute laws subsequently enacted for Letters Patent for inventions all therefore derived their charter, as it were, from the Statute of Monopolies, and therefore it is essential that valid Letters Patent for invention must relate to a manner of new manufacture. The question of novelty is not dealt with here, but the point under consideration is whether the existing laws being limited to patents for a manufacture are adequate to cover what is desirable in the public interest.

The point is raised in view of two decisions of the present Solicitor-General, Sir Ernest Pollock, in which he held that certain matters did not relate to a manner of new manufacture; therefore, patents for them were refused. These decisions have just been reported ("Reports on Patent Cases," vol. xxxviii, June 30, 1920). The first application related to a certain manner of coating articles, especially war articles, with various colours for rendering them invisible. The first three claims were for processes and the fourth claim for the articles coated.

The first claim read: "A process for rendering an article invisible consisting of coating the surface of the article with bars of varying size and of alternate warm and cold colours, substantially as described." The fourth claim covered an alleged new article of manufacture made according to the above process, in which the bars are disposed in patches of dark, light and intermediate tones so arranged that the dark and light patches are blended by an intermediate tone as illustrated in certain figures.

The chief examiner who dealt with this matter in the first instance stated that the alleged process appeared to be merely a direction to adopt a particular scheme of colouring for purposes of camouflage, and that in carrying out the invention a suitable scheme would be selected, but the operation of the coating would be effected by any known process and the article of manufacture would be the product of the known process. The Solicitor-General, on appeal, agreed with the chief examiner, and held that the invention did not cover a claim for a particular article to be made under a particular scheme, for it indicated that the process was only a process in this sense, that if one were to follow certain rules in selecting colours and apply them to any article some measure of invisibility and some measure of inviolability from attack would be secured. In his view there were several methods of selecting any number of different processes which would give a greater or less degree of invisibility, but these gave no result in the sense of manufacture, that is an article that has been manufactured as the result of the process. He therefore found that it was a matter of ingenuity falling outside that which can be protected.

In the second case the patent application related to a method of defence and attack against submarines in which a line of listening vessels provided with submarine detectors is placed between lines of chasing and attacking vessels provided with detectors and with means for attacking submarines, the said chasing vessels on receiving a signal showing the presence and approximate position of an enemy submarine converging upon the area indicated.

It was agreed that if the alleged invention were a mere arrangement of destroyers and submarines it would not be a manner of manufacture, but it was admitted that destroyers and submarines could be connected, not only by wireless, but by an arrangement of actual wires, and that, therefore, the scheme or arrangement was differentiated from other arrangements and, in fact, indicated that there must be some new manner of manufacture.

The Solicitor-General summed up his view on which he rejected the application in this way: "Really, when one strips it of the arguments which are possible and which can be found scattered through these cases (the previously-decided cases to which he had been referred), it is a mere arrangement of the component parts of a squadron of vessels carrying out their duties for the defence of the nation."

These are two important decisions which affect inventors of processes or schemes in which, although considerable ingenuity is displayed, the resulting product is not one manufactured as the result of the process. Such cannot be protected by the present law relating to Letters Patent for inventions. The only other possible means for protecting schemes or the like are under the laws relating to the registration of design or copyright. Neither of these would be suitable in cases of the kind typified by the two examples dealt with above.

This is not the first time, of course, that matters of this class have been considered, and it has before been proposed that it may be well to modify the provision of the Statute of Monopolies or such other statute as may be necessary to enable some measure of protection to be given to those who devise ingenious schemes which are at the same time useful.

MINERALS IN PERU.—According to the *Boletin del Cuerpo de Ingenieuros de Minas del Peru*, the total value of the mineral output of that State in 1918—taking one Peruvian libra to be equal to one British sovereign—was 8,324,960*l.*, a decrease of roughly 10 per cent. on the value of the output for the preceding year.

THE WORKS OF MESSRS. ROBEY AND CO., LIMITED, OF LINCOLN.

(*Concluded from page* 71.)

THE UNIFLOW ENGINE.

It has long been recognised that when steam is carried through a large range of expansion in a single-cylinder engine of the ordinary type, the temperature changes within the cylinder constitute a serious source of loss. If, for example, steam is admitted at a pressure of 180 lb. per square inch and exhausted at a vacuum of 26 in., the temperature will drop during expansion from about 380 deg. F. to 126 deg. F., with a corresponding cooling of the walls of the cylinder. The incoming steam during the next stroke has to flow through valves and ports and into a cylinder, all of which a second before were in contact with the comparatively cold steam exhausting after the previous stroke. The metallic surfaces thus become re-heated at the expense of the incoming steam, much of which becomes condensed in the process. This interchange of heat takes place at every stroke of the engine, and is responsible for a material loss. The provision of separate steam and exhaust valves mitigates, to a certain extent, the loss from initial condensation, but even with such an arrangement there is a considerable waste of heat from the cause we have mentioned. Compound and triple expansion engines owe their greater economy entirely to their ability to utilise a large range of expansion without heavy condensation losses owing to their smaller temperature ranges per cylinder, but the greater cost and complications of such engines, as compared with simple engines, have also to be taken into account. A compound or triple expansion engine, of course, gives no more power than would be obtained from the same amount of steam expanding in its low-pressure cylinder, the provision of high-pressure and intermediate cylinders adding nothing to the power of an engine, but only enabling the expansion of the steam to be carried out with less loss than in a single cylinder. It follows that if a single-cylinder engine could be devised which would avoid the heat losses inherent in the ordinary type it could compete in economy with the compound or triple-expansion engine, and would have substantial advantages over such engines in respect of simplicity of construction.

In the Uniflow engine, of which Messrs. Robey and Co. are the largest British manufacturers, the whole range of expansion of the steam from boiler pressure to condenser pressure is carried out in a single cylinder. The cylinder is longer than the usual proportions, and the piston is nearly half the length of the cylinder. Steam is admitted by drop valves placed at the ends of the cylinder and is exhausted through a ring of ports around the centre of the cylinder which are uncovered by the piston as the latter approaches the end of each stroke. There are thus no exhaust valves at all, the motion of the piston controlling the opening and closing of the exhaust ports. The hot live steam entering the cylinder cannot approach anywhere near these comparatively cold ports or reach the cooled cylinder walls adjoining them, as the piston covers all the cooled area. Further, the exhaust steam does not flow over or near the hot inlet valves and ports, so that the latter suffer the minimum of cooling as the temperature of the working steam is reduced by expansion. It will therefore be seen that, so far as possible in a reciprocating engine, a steady temperature gradient exists within the cylinder with a consequent minimum of loss due to the interchange of heat between the steam and the metallic surfaces. This permits of a large ratio of expansion without undue condensation losses, and in fact a simple Uniflow engine is claimed to equal a triple expansion engine in efficiency when working under the same steam conditions.

The mechanical simplicity of the Uniflow engine is also very noticeable. The length of the piston obviates the necessity for a tail rod, so that as compared with a tandem compound Corliss or drop-valve engine, the Uniflow has one piston rod gland as against three, and two valves only as against eight. The valves are located on the top of the cylinder and are operated by cams driven by eccentrics mounted on a lay shaft. A centrifugal shaft governor varies the position of these eccentrics according to the speed of the engine, and so alters the time of cut-off. The type of valves and the general construction of the Uniflow engine render it very suitable for the highest superheats which are met with in practice. It is fitted with forced lubrication to the main bearings, connecting rod and guides and in all other respects follows the best modern practice. The single-cylinder type is built for general stationary work in eighteen sizes ranging from 60 h.p. to 1,000 h.p., but the uniflow principle has been embodied in the undertype engines with locomotive boilers, which have been for so long a speciality of Messrs. Robey and Co. The undertype uniflow engines range from 24 b.h.p. to 160 b.h.p. non-condensing, and from 30 b.h.p. to 200 b.h.p. condensing, but they possess an overload capacity of about 50 per cent. which can be utilised in emergency.

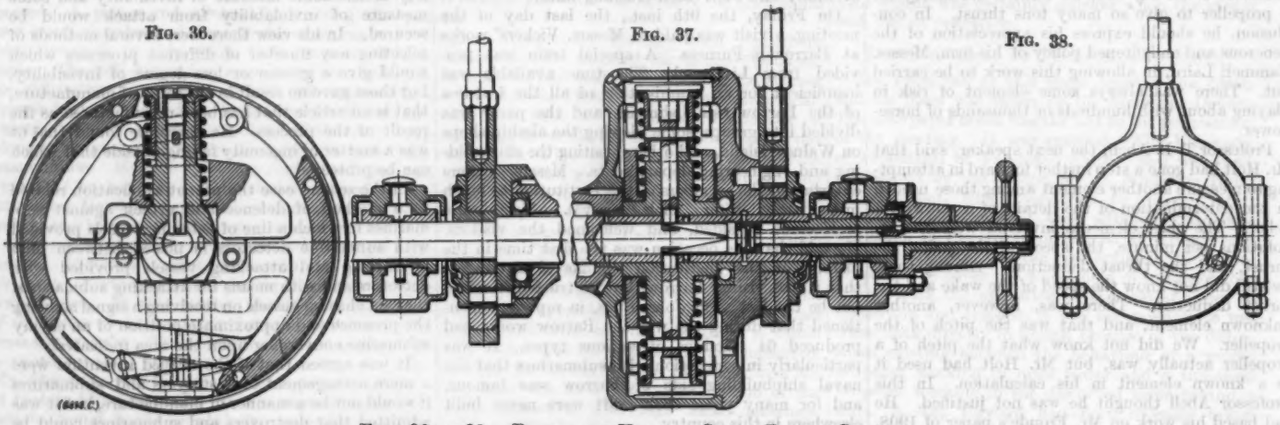
The arrangement of a Uniflow engine is shown in Figs. 30 to 32, Plate XIII, facing page 118. The engine in question develops 1,250 brake horse-power in one cylinder and transmits its power by means of a rope-pulley. A jet condenser situated at the back of the pulley and below the floor level provides for condensation, and a double-acting wet air pump, driven by an eccentric from the crank-shaft, maintains the vacuum. This air pump has neither foot valves nor bucket valves, and resembles in its action the Edwards type of pump, except that it is double acting and is placed horizontally. Fig. 33 shows a Uniflow engine of 1,100 i.h.p. direct coupled to an electric generator in Messrs. Robey and Co.'s own power-house. This engine, which runs at 120 r.p.m., has a single cylinder 35 in. diameter by 40 in. stroke, and its simple and clean appearance are well illustrated in the engraving. It works with a steam pressure of 200 lb. per square inch and a superheat of 200 deg. F.

Figs. 34 and 35, Plate XIII, give sections through a typical Uniflow cylinder which will be readily understood from the description we have already given. The control of the Uniflow engine is effected by a governor situated on the lay shaft, details of the governor gear being given in Figs. 36 to 38 on this page. The action of the governor is to cause the eccentric sheaves to move on the rectangular blocks shown, and thus to vary the cut-off of the steam.

THE ROBEY COMPOUND SUPERHEATER ENGINE.

For situations where an extremely compact yet highly economical steam plant is required, the compound superheater engine of the type illustrated in Fig. 30, on the opposite page, is often advantageous. The floor space necessary is small as compared with other kinds of plant, and owing to the self-contained design the cost of foundations and other incidentals to installation is also a minimum. The absence of all steam pipes connecting the engine with the boiler not only simplifies erection in out-of-the-way places, but at the same time does away with what is often a source of considerable loss. The efficiency of engines of the type in question is, moreover, remarkably good, and this fact, combined with the other advantages to which we have alluded, has brought about their wide adoption. A further consideration is that a single attendant only is required, the whole of the plant being visible and accessible to him.

FIG. 36. FIG. 37. FIG. 38.



FIGS. 36 TO 38. DETAILS OF UNIFLOW STEAM ENGINE GOVERNOR.

The fire-box of the Robey superheater engine is of the circular corrugated type, terminating in a tube plate, from which fire tubes extend to the back tube plate at the smoke-box end of the boiler. This latter tube plate is no larger than necessary to carry the tubes, and is fastened to the inside of the end plate of the boiler shell by means of bolts. Similarly the front end of the fire-box is bolted to the front of the boiler, and so, by removing the bolts, the whole of the fire-box and tubes can be withdrawn from the boiler shell for inspection or cleaning. To do this involves no interference with the tubes themselves, nor does it require more skill than any intelligent man possesses. When the fuel to be used is of a bulky nature, such as straw, wood logs, bagasse, or stalks of cotton, maize, &c., the fire-box is extended at the front, the extension being lined with firebrick, and supported on wheels for ready removal. Furthermore, by the fitting of a stepped grate, sawdust, rice or coffee husks, tannery refuse, &c., can be used for fuel, and, as another alternative, oil burners can be fitted if desired.

The superheater consists of a large number of small diameter steel tubes arranged in a zig-zag fashion and occupying practically the whole inside of the smoke-box. Three steel headers lie longitudinally in the smoke-box, one at the top and two at the bottom. The top header is divided into two parts, the steam from the stop valve entering the one nearest the chimney, passing down through two sets of the zig-zag tubes to the bottom headers and returning by other similar tubes to the inner and hotter end of the top header. It passes thence to the engine stop valve. Another valve provides for the isolation of the superheater, which can be withdrawn from the smoke-box complete when desired.

The engine proper is of the compound type, having cylinders fitted with separate liners which are forced into the main casting and bored in position. A by-pass to the low-pressure cylinder enables the engine to be run as a high-pressure engine when starting under an exceptional load or in other emergency. The high-pressure cylinder is usually

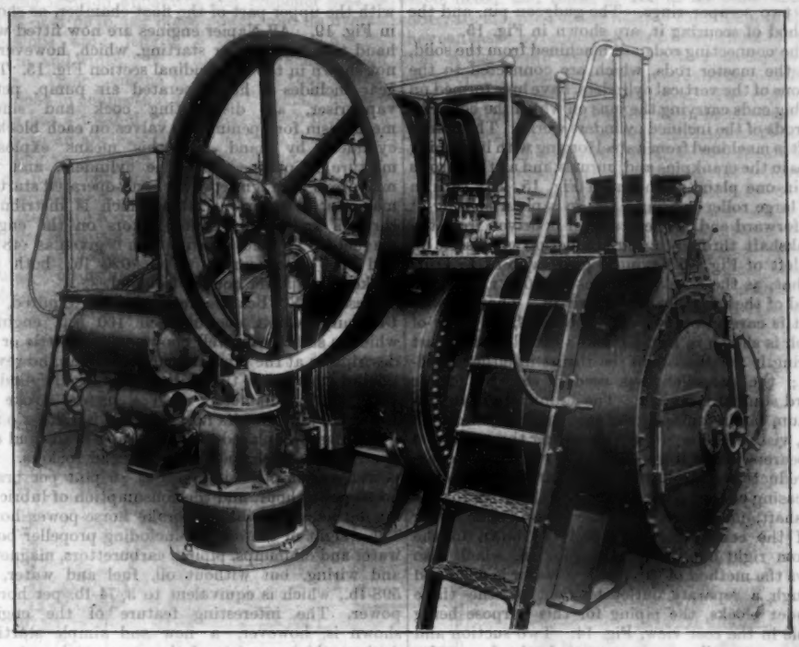


FIG. 39. SEMI-PORTABLE SUPERHEATER CONDENSING ENGINE.

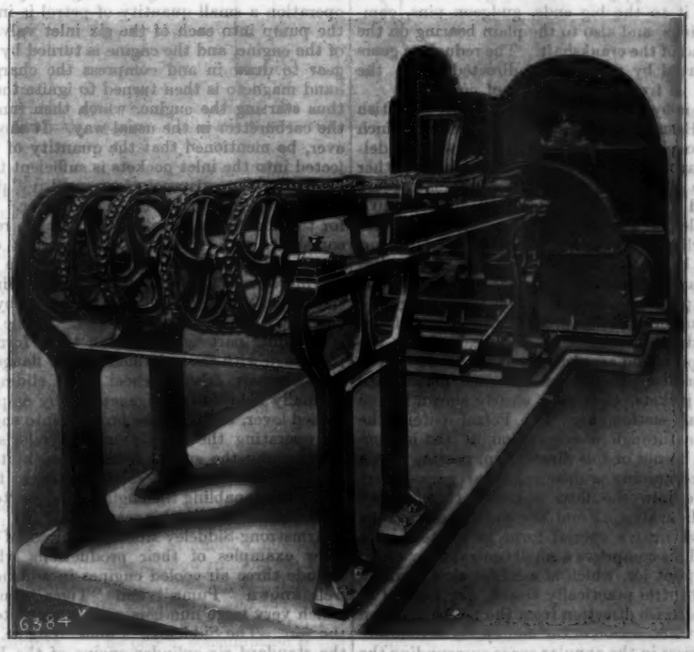


FIG. 40. FIBRE DECORTICATING MACHINE.

fitted with a piston valve on account of the high superheat with which the engine works, but Messrs. Robey and Co. also fit drop valves to the larger sizes. In any case the engine is governed by a crankshaft governor which varies the point of cut-off in the high-pressure cylinder. The low-pressure eccentric has a hand adjustment.

When the superheater engine is arranged for condensing, as it usually is on account of the greater economy so obtained, the condenser is either of the surface or jet type according as to whether the nature of the water renders the conservation of the condensed steam for boiler feed necessary or not. Before passing to the condenser or to the atmosphere, as the case may be, the exhaust steam is taken through a feed-water heater of the surface type, which raises the feed-water temperature to 170 deg. F. or so, without contaminating it with oil from the cylinders. The air pump for the condensing engines is of the double-acting central inlet type without either foot valves or bucket valves. It is driven by an eccentric on the crankshaft.

The Robey superheater engines are built as condensing engines in 15 sizes ranging in power from 40 brake horse-power at 220 r.p.m. to 450 brake horse-power at 160 r.p.m. The weights in the case of these sizes of engines having jet condensers range from 240 cwt. to 1,400 cwt. In sizes above 225 brake horse-power the flywheel takes the form of a rope pulley grooved for 1¼ in. ropes. In the case of non-condensing engines the power is about 25 per cent. less at their most economical load. The weight is about 5 per cent. less than when equipped with condensers.

ROBEY DECORTICATING MACHINERY.

Messrs. Robey and Co., Limited, have been particularly successful in connection with the somewhat difficult job of devising and building machinery for the extraction of fibre from the sisal leaf, a process which has to be carried out by native labour and under all the disadvantages as regards maintenance and repairs which work in new and tropical countries involves. The sisal plant (*Agave sisalana*) is a kind of cactus native to Mexico which produces a number of thick, pulpy, sword-like leaves about 5 ft. long. Its cultivation has been introduced into East Africa, where it flourishes exceedingly well on the coast plantations where the coral soil is unsuitable for ordinary crops. The extractable fibre constitutes only from 3 per cent. to 5 per cent. of the weight of the raw leaf, but the length and tensile strength of the fibre combined with its stiffness and elasticity render it especially suitable for certain purposes, such as the manufacture of binder-twine, for which it is extensively employed.

The principal machine in connection with a fibre-extraction plant is the decorticator, the appearance of which is illustrated in Fig. 40, on this page. The sisal leaves, in the green condition in which they are harvested, are placed transversely upon the five conveyor chains, shown prominently in the illustration, and are carried by them into the machine. They are delivered by the conveyor chains to the main feed chain close to the point at which this makes contact with a grooved pulley round which it passes. The leaves are gripped by their centres between the feed chain and the grooves of the pulley and the overhanging ends on one side are guided so that they have to pass between a threshing drum armed with blunt knives on its circumference, and a "concave," or fixed curved surface forming a partial housing for the threshing drum. The action of the knives on the drum is to scrape the half of the leaf being operated on in a longitudinal direction, the leaf being held up to the blades by the support of the concave. On emerging from the concave that end of the leaf consists only of a number of fibres, the whole of the pulp having been beaten away. A blast of air, furnished by a fan on the machine, drives the hanging fibre aside and causes it to be nipped between the feed chain and a second grooved pulley immediately that the grip upon the central part of the leaf is released. The second end of the leaf, including the central portion by which it was originally held, then passes between a second threshing drum and concave, and when the leaf emerges from this concave nothing remains of it but the fibres. These are then delivered on to a copper bar from which they hang by their centres, and they are transferred by natives to poles and carried away to dry suspended in the air.

All working parts of the machine are either of solid phosphor bronze, or are sheathed with similar metal, as the acid juices of the sisal leaf rapidly attack iron. The standard Robey decorticator, inclusive of a 16-ft. feeding table, is 29 ft. 6 in. long by 8 ft. 6 in. wide. It weighs altogether some 11 tons, but is specially sectionalised for convenience in transportation, so that the heaviest single part is less than 2 tons in weight. The standard machine will handle 13,000 leaves an hour, producing from 2½ tons to 3 tons of fibre per 10-hour day, according to the condition of the leaves. It is gratifying to know that British-made machines of the type in question are rapidly superseding the "Neu Corona" Krupp-built decorticator which used to hold the lead, and that recent competitive trials have shown them to be distinctly more efficient, both as regards quantity of leaves handled, and percentage of fibre extracted, than either the German or American designs. One item of the trials was to supply each of the competing machines with 20 tons of raw leaves, and to note both the

time taken to decorticate them and the percentage of fibre recovered. The Robey machine completed the job in 146 minutes 20 seconds and gave 3·765 per cent. of fibre, the German machine took 159 minutes 42 seconds but yielded only 3·435 per cent. of fibre, while the American machine took 173 minutes 52 seconds and furnished 3·515 per cent. of fibre.

THE INTERNATIONAL AERO EXHIBITION.

(*Continued from page* 79.)

In addition to the aeroplanes illustrated and described in our last issue, the exhibition includes a very representative collection of aero engines, which are shown by nine manufacturers. There are no startling innovations such as were usually to be found in the earlier exhibitions, the majority of the models shown being types developed and perfected during the course of the war. Most manufacturers appear to have contented themselves with improvement in detail, or by increasing the size of units, and a noticeable feature is that greater reliability is now sought for rather than reduction in weight. Water-cooled engines of the motor-car type are more in evidence than other types, but a number of air-cooled engines, both of the rotary and fixed radial types, are also shown, and there is one four-cylinder air-cooled engine of the motor-car type. This was referred to near the conclusion of our last week's article on page 79 *ante* and, as there stated, it is placed with its crankshaft vertical and with the cylinder heads in the slip stream of the air screw. Although there is a marked tendency to increase the size of units, there also appears to be a demand for a small air-cooled engine of from 30 hp. to 50 h.p. for light single-seater machines intended for private users, and one or two makers are showing models designed to meet this demand.

The 450 h.p. engine exhibited by Messrs. D. Napier and Son, Limited, 14, New Burlington-street, London, W. 1, unfortunately, was not produced in sufficient quantities to render much service to the country during the war. It has, however, acquired an excellent reputation since the signing of the Armistice, having been used, for instance, in an altitude record flight in which a height of 30,500 ft. was reached at Martlesham Heath in January of last year. This flight, we may remind our readers, was made by Capt. Lang in a D.H. 9 aeroplane carrying an observer as well as the pilot. The total weight of the machine was 3,440 lb. and the height of 30,500 ft. was reached in 68 minutes. It should, however, be pointed out that the figure mentioned was that indicated by the aneroid, and that the true height above the ground reached was 27,350 ft. We reproduce drawings and photographs of the engine on Plates XIV and XV which accompany this issue, and one of the Claudel-Hobson carburettors used with it is illustrated on page 107. Its clean and compact appearance will be noticed from the side and rear views given in Figs. 13 and 14 on Plate XIV, but the property of compactness will perhaps be more evident when we mention that the overall dimensions are: length, 4 ft. 10 in.; width, 3 ft. 6 in.; and height, 3 ft. The twelve cylinders, it will be seen, are arranged in three groups of four each with an angle of 60 deg. between them after the manner of an inverted broad arrow, and this feature of the design, of course, enables the length to be reduced in comparison with an ordinary V-type engine of the same output.

The weight of the engine dry, complete with reduction gear, propeller boss, carburettors, and induction pipes, is 850 lb., which works out at 1·89 lb. per horse-power at the normal speed of 2,000 r.p.m. The construction of the engine is well shown in Figs. 15 and 16 on Plate XV, Fig. 15 being a longitudinal section through the middle group of cylinders and Fig. 16 a complete transverse section. The cylinders, which have a diameter of 5½ in. with a piston stroke of 5½ in., are steel forgings, machined all over and fitted with steel water jackets. A detachable cylinder head of aluminium containing the inlet and exhaust passages, and supporting the valve operating mechanism, is fitted to each cylinder as shown in the transverse section, Fig. 16. There are two inlet and two exhaust valves to each cylinder operated directly by two overhead camshafts, the latter being driven through bevel gearing by vertical and inclined shafts from the crankshaft; the method of driving the vertical shafts is shown on the right of Fig. 15. The whole of the valve mechanism, it may be added, is enclosed in detachable oil-tight aluminium covers, one of which is fitted to each group of cylinders. The pistons, of which sections are given in both Figs. 15 and 16, are of aluminium alloy, and are fitted with two gas and two scraper rings. The gudgeon pin, and the method of securing it, are shown in Fig. 15.

The connecting rods are machined from the solid, and the master rods, which are connected to the pistons of the vertical cylinders, have lugs formed on the big ends carrying the pins on which the connecting rods of the inclined cylinders work. The crankshaft is machined from a steel forging with lightening holes in the crankpins and journals, and all the throws are in one plane as shown in Fig. 15. It runs in five large roller bearings, and in a plain bearing at the forward end. The propeller is driven from the crankshaft through a spur reduction gear seen on the left of Fig. 15 having a gear ratio of 1 : 1·52, so that, as the crankshaft runs at 2,000 r.p.m., the speed of the propeller is 1,320 r.p.m. The propeller shaft is carried on two roller bearings, only one of which is shown in Fig. 15, and a double ball thrust bearing is fitted to take the thrust in either direction; the propeller boss used is the No. 4 Air Board standard design. The crankcase is an aluminium casting suitably stiffened and provided with lugs, visible in Fig. 16, for mounting the engine on its bearers. The front end of the crankcase covers the reduction gearing, and to the rear end is attached the casing covering the pumps and the drive for the camshaft, magnetos and water pump. The latter is of the centrifugal type and is shown in the bottom right-hand corner of Fig. 15, which also shows the method of driving it. Water is delivered through a separate outlet to each of the three cylinder blocks, the piping for this purpose being visible in the rear view, Fig. 14. Two suction and one pressure oil pumps are fitted, the former for draining the crankcase sump and the latter drawing oil from the supply tank, through a filter, and supplying it to the big ends, gudgeon pins, camshaft bearings, and also to the plain bearing on the forward end of the crankshaft. The reduction gears are lubricated by a jet of oil directed on to the teeth just in front of the point of contact.

Ignition is by two 12-cylinder magnetos of British Thomson-Houston Company's manufacture, which supply two plugs in each cylinder. Two Claudel-Hobson carburettors, one double and the other single, are fitted and drawings of the latter are reproduced in Figs. 17, 18 and 19 on page 107. The double carburettor supplies the front and vertical cylinder blocks and the single carburettor, which can be seen on the right of Fig. 13, supplies the starboard cylinder block. Water-jacketed steel induction pipes are bolted to the inlet flanges of cast aluminium induction manifolds on the cylinder heads, and the carburettors are carried by the induction pipes and are also stayed to the crankcase. The carburettors themselves are also fitted with hot-water jackets, as is most clearly shown in the longitudinal section Fig. 19. Petrol enters the carburettor through a connection at the bottom right-hand corner of this illustration, passing into a chamber containing a hemispherical gauze filter and thence into the float chamber through the usual needle valve. From the float chamber the petrol flows into a special form of jet termed a diffuser. This comprises a small central tube which forms the pilot jet, which is used for slow running with the throttle practically closed, *i.e.*, rotated in an anti-clockwise direction from the position shown in Fig. 19. The action of the main jet is as follows: the petrol rises in the annular space surrounding the pilot jet and flows into the adjacent annular space through a number of small holes in the intervening tube. Surrounding last-mentioned space is a solid tube, and outside the whole is another tube with holes near its lower end. When the throttle is opened air passes through these holes up the outer annular space and down the next annular space, forcing the petrol through the holes in the inner wall of this space so that it passes with the air into the space surrounding the pilot jet, and finally emerges through the upwardly inclined holes shown near the tip of the jet. In its passage through the diffuser the petrol, as can easily be imagined, is broken up and intimately mixed with the air, so that it emerges in a finely divided cloud-like form and is immediately carried away by the main current of air through the throat. The altitude compensation provided is of the Claudel vacuum control type, and is effected by adjusting a valve fitted in a passage connecting the throat with the upper part of the float chamber, as shown in Fig. 19. All Napier engines are now fitted with hand turning gear for starting, which, however, is not shown in the longitudinal section Fig. 15. This gear includes a hand-operated air pump, petrol vapouriser, air distributing cock and simple mechanism for opening the valves on each block of cylinders by hand. By this means explosive mixture is pumped into the cylinders, and the mixture is then ignited by a hand-operated starting magneto, the current from which is distributed through special distributor rotors on the engine magnetos. The fuel consumption is given as ·48 lb. and the oil consumption as ·020 lb., both per brake horse-power hour at full load.

Messrs. W. Beardmore and Co., Limited, of Dalmuir, exhibit one of their 160 h.p. engines, which is sufficiently well known to need little or no description at the present time. We may, however, remind our readers that it has six vertical cylinders 142 mm. in diameter, with a piston stroke of 175 mm., and that its normal speed is 1,200 r.p.m., The valves are placed in the cylinder heads and are operated by push rods and overhead rockers. Its petrol consumption is given as ·6 pint per brake horse-power hour, and the consumption of lubricating oil as ·028 pint per brake horse-power hour. The weight of the engine, including propeller boss, water and oil pumps, piping, carburettors, magnetos and wiring, but without oil, fuel and water, is 598 lb., which is equivalent to 3·74 lb. per horse-power. The interesting feature of the engine shown is, however, a new and simple starting device, which consists of three essential parts: a hand-operated magneto, a petrol pump and mechanism for turning the engine by hand. In operation a small quantity of petrol is injected by the pump into each of the six inlet valve pockets of the engine, and the engine is turned by the hand gear to draw in and compress the charges. The hand magneto is then turned to ignite the mixture thus starting the engine, which then functions on the carburettor in the usual way. It should, however, be mentioned that the quantity of petrol injected into the inlet pockets is sufficient to run the engine for several revolutions until it "picks up" sufficiently to run on the carburettor. The gear for turning the engine is located on the rear of the camshaft, and it consists of a flange, on which clutch teeth are cut, bolted on to the camshaft driving wheel. In fitting it, the usual casing for the timing gear is removed and replaced by a casing carrying a worm and worm wheel. Inside the latter is a sliding part having clutch teeth formed on it to engage with those formed on the flange fixed to the camshaft driving wheel. The sliding part is normally held out of engagement by a spring-controlled lever, but it can be brought into engagement by operating the lever from the pilot's cockpit. For turning the engine from the cockpit a chain, or other form of drive, is connected to the worm shaft, thus enabling the engine to be started by the pilot without leaving his seat.

Armstrong-Siddeley Motors, Limited, of Coventry show examples of their productions which now include three air-cooled engines in addition to the well known "Puma" and "Tiger" engines, of which very large numbers were constructed during the war. The Siddeley "Puma" engine, which is the standard six-cylinder engine of the Royal Air Force, has the cylinders arranged vertically in a straight line and in two blocks of three each, steel barrels being screwed into a common aluminium head to form each block. There are two exhaust valves and one inlet valve to each cylinder head and the valves are operated by an overhead camshaft. The cylinders are 115 mm. in diameter and the piston stroke is 190 mm., the engine developing 246 brake horse-power when running at the normal speed of 1,400 revolutions per minute. At this speed, the petrol consumption of the engine is

17 gallons per hour, or ·55 pint per brake horse-power hour, and the consumption of lubricating oil is 10 pints per hour which is equivalent to about ·04 pint per brake horse-power hour. Lubrication is effected by a double pump, one part of which supplies oil to the crankshaft bearings, while the other part draws oil from the sump and returns it to the tank. The weight of the engine dry, but including ignition apparatus and propeller boss, is 636 lb., or 2·59 lb. per horse power, and its overall dimensions are: length, 5 ft. 10 in.; height, 3 ft. 5 in. and width, 2 ft. The cylinder construction of the "Tiger" engine is similar to that above-mentioned in connection with the "Puma," but the former has a total of 12 arranged in two lines of 6 each with an angle of 60 deg. between them. The cylinders are 160 mm. in diameter and the stroke is 180 mm., but this engine develops 500 brake horse-power at 1,500 revolutions per minute, and it is fitted with a reduction gear, through which the propeller is driven at 833 revolutions per minute. The lubrication system also differs from that of the "Puma," oil being supplied by a main pump to a triple distributing pump which feeds three main bearings of the crankshaft. The oil then passes to

Fig. 17.

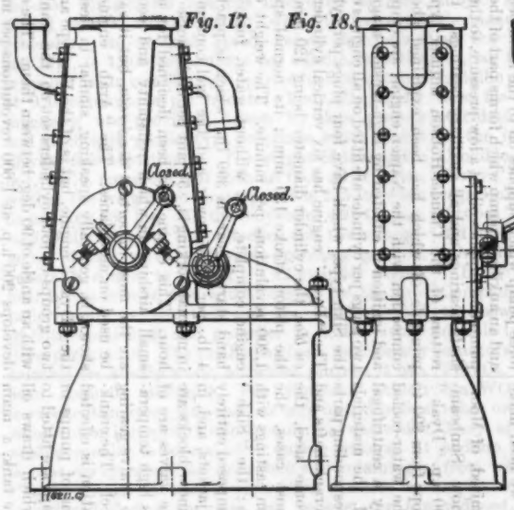


Fig. 18.

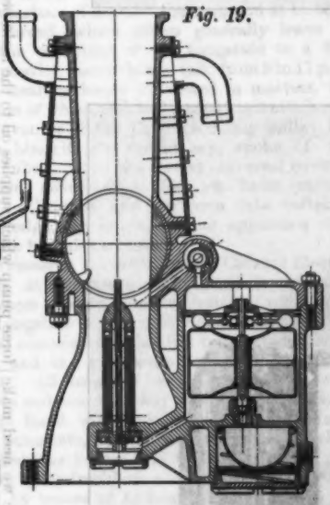


Fig. 19.

the crankpins and back through the four remaining bearings of the crankshaft to the sump, from which it is drawn by two return pumps, one fitted at each end of the crank-case. An electric motor mounted on the crank-case is used for starting the engine. At normal speed the consumption of petrol and lubricating oil are given as 35 gallons and 2½ gallons per hour, respectively, which work out to ·56 pint and ·04 pint per horse-power hour, and the total weight of the engine dry is 1,600 lb. or 3.2 lb. per horse-power. Its overall dimensions are: length, 6 ft. 10 in.; height, 3 ft. 4 in., and width, 2 ft. 10 in.

The above-mentioned engines are both water-cooled, while the three remaining exhibits are all of air-cooled engines. Two of the latter are of the fixed radial type, one developing 300 h.p, and the other 150 h.p., while the third is a small engine with twin opposed cylinders rated at 45 h.p. though it can actually develop over 50 h.p. The last mentioned engine is intended for use in small single-seater machines where simplicity and low running costs are of more importance than very high speed. The two cylinders are each 5 in. in diameter and the stroke is also 5 in., while the normal speed is 1,600 revolutions per minute. The petrol consumption is .35 gallon per hour, the oil consumption 2·5 pints per hour, the former being equivalent to ·62 pint per horse-power hour and the latter to ·055 pint per horse-power hour. The weight of the engine, including ignition system and propeller boss, is 170lb. or 3.78 lb. per horse-power. The 150 h.p. radial engine has seven cylinders of the same dimensions as those of the twin engine and its normal speed is 1,500 revolutions per minute. The cylinders are composed of steel barrels screwed into aluminium heads and they are fixed to the crank-case in such a manner that they can be easily detached; one inlet and one exhaust valve are provided for each cylinder. Roller bearings are used for the crankshaft and all other bearings are either of the ball or roller type. Lubrication is effected by a double oil pump which supplies oil to one end of the crank-case and withdraws it from the same end after it has circulated to the other end and back again. Dual ignition, by means of a magneto and a Remy ignition set, is fitted, and these, as well as all other accessories, are mounted on the front of the engine so that they can easily be removed without disturbing the engine. A distributor is fitted for starting the engine by means of compressed air, and a ring exhaust manifold built up in five sections is supplied. The engine is supported by four feet extending from the back of the crank-case, and its length from back to front is 2 ft. 9½ in.; the diameter overall is 3 ft. 6 in. The petrol consumption comes out at ·55 pint per brake horse-power hour and the oil consumption to ·05 per brake horse-power hour, while the total weight of the engine is 390 lb., which is equivalent to 2·6 lb. per horse-power. The 300 h.p. engine is almost identical in design with the 150 h.p. engine, and is practically two of the latter placed one in front of the other. It is, however, supported on seven feet instead of four, and the ring exhaust manifold is composed of six sections instead of five. The diameter is, of course, the same as that mentioned above for the 150 h.p. engine, but the overall length is increased to 3 ft. 5 in. As would be expected, the petrol consumption is the same for both engines, but the oil consumption, for some reason that we are unable to explain, is larger for the 300 h.p. engine and comes out at ·06 pint per brake horse-power hour. The weight per horse-power is noticeably less for the larger engine, being 2·26 lb. as compared with 2·6 lb., the figure given above for the smaller engine; the total weight of the 300 h.p. engine dry is 680 lb. but this figure includes the dual ignition gear and the propeller boss.

In addition to the Bristol aeroplanes illustrated and described in our last issue on page 75 *ante*, the Bristol Aeroplane Company, Limited, of Filton House, Bristol, have another stand on which are shown two radial air-cooled engines, the patents, designs and manufacturing rights of which they have recently acquired from the Cosmos Engineering Company, Limited, also of Bristol. One of these engines, which will in future be known as the Bristol "Jupiter," has nine cylinders of 5½-in. bore and 7½-in. stroke arranged in one plane. It is made in two types, one with an epicyclic reduction gear having a ratio of 1: ·656, and the other driving the airscrew directly. With the reduction gear, the engine can run at 2,000 revolutions per minute and develop 500 brake horse-power, while the airscrew rotates at 1,300 revolutions per minute. The ungeared engine, which also develops 500 brake horse-power weighs only 698 lb., including carburettors, magnetos and propeller hub, but without the electrical starter and exhaust pipes. Both engines are, however, conservatively rated for a maximum output of 450 horse-power, and, on this rating, the weight per horse power comes out at 1·551 lb., which is, we believe, the lowest figure yet attained. With the reduction gear the engine weighs 805 lb. and the weight per horse power is then 1·79 lb.

The cylinders and fins are turned from solid-steel billets, and the cylinder heads, by means of which the greater part of the heat is dissipated, are of aluminium. There are two inlet valves and two exhaust valves to each cylinder, the induction pipes leading to the former being fitted with Y branches near their outer ends leading to each valve. The exhaust is also conducted away through two separate heads, the whole arrangement, it is claimed, ensuring an easy flow of mixture to the cylinders and a free passage of air over the cylinder heads. The crank-case is an aluminium casting in two parts, jointed in the vertical plane and held together by nine long bolts, these bolts being also used for mounting the engine on the fuselage. The back of the crank-case is closed by two covers—a central one which carries the magnetos, oil pumps and other accessories, and an annular one fitted over the induction chamber, which is one of the special features of the engine. This chamber is annular and of circular cross-section, and it contains an aluminium casting in a form of a three-start helice. The interior of the chamber is machined all over and the edges of the helical casting are also machined to fit the chamber fairly closely. Three separate helical passages are thus formed in the chamber, and each passage is connected to three induction pipes and one carburettor, three of the latter being used with each engine. The arrangement provides an easy path for the mixture, and also isolates the cylinders into three groups, so that, if any one cylinder or carburettor fails the engine will function perfectly on the remaining six cylinders, though, of course, at reduced power.

Another interesting feature of the engine is the method adopted for reducing the load on the big end bearing, which tends to become excessive in engines of this type. The bearing pressure is due mainly to the inertia and centrifugal forces which are always greater than the pressures due to the explosions. The latter, in fact, tend to reduce the bearing pressure, but as, at great altitudes, the explosions get weaker while the inertia and centrifugal forces remain constant, the bearing pressure becomes higher from this cause. It would be possible to reduce the pressure by lengthening the bearing, but there are obvious objections to this course, and in the "Jupiter" engine the difficulty is surmounted by the employment of bob weights. Two of these weights are suspended from the big end of the master rod, so that they lie parallel with, and close to, the crankshaft webs and main balance weights. At their outer ends the bob weights are connected to the balance weights by means of a slotted and hardened die, so that they are forced to rotate with the crankshaft, but are free to exert a pull radially outwards. This pull acting on the master rod in the opposite direction to the main inertia and centrifugal forces helps to neutralise the latter, and so reduces the load on the big end bearing. The petrol consumption of the engine when running at 1,650 revolutions per minute, and developing 400 horse-power, is 222·8 lb. per hour or ·557 lb. per horse-power hour. The other engine shown by the Bristol Company is known as the Bristol "Lucifer," and has three radial cylinders arranged in the form of an inverted Y. The cylinders are similar in design and construction to those of the "Jupiter" engine and have the same diameter, but the piston stroke is only 6½ in. instead of 7½ in. The engine is rated at 80 horse-power, although it is guaranteed to develop 100 horse-power at 1,600 r.p.m. No reduction gear is fitted on this engine, and it is not provided with the helical induction chamber or the bob weights for reducing the bearing pressure. Its total weight is 300 lb.

An interesting collection of aero engines, all of the air-cooled rotary type, is shown at the stand of Messrs. Gwynne's Engineering Company, Limited, of Hammersmith, London, W.6, who turned out these engines in large numbers during the war. The exhibit includes one of the well-known B.R.2 nine-cylinder engines, which runs at an average speed of 1,300 r.p.m. and develops about 230 h.p. at that speed. The weight of this engine complete

800-900-H.P. SUNBEAM-COATALEN "SIKH" ENGINE AT THE INTERNATIONAL AERO EXHIBITION AT OLYMPIA.

CONSTRUCTED BY THE SUNBEAM MOTOR CAR COMPANY, LIMITED, ENGINEERS, WOLVERHAMPTON.

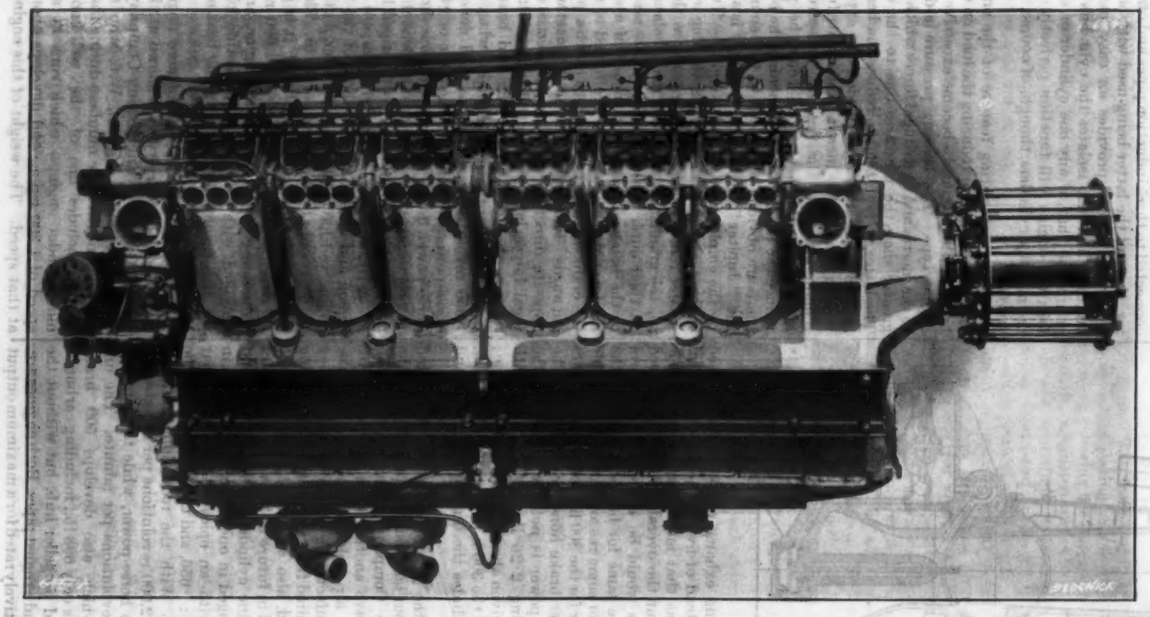


FIG. 20.

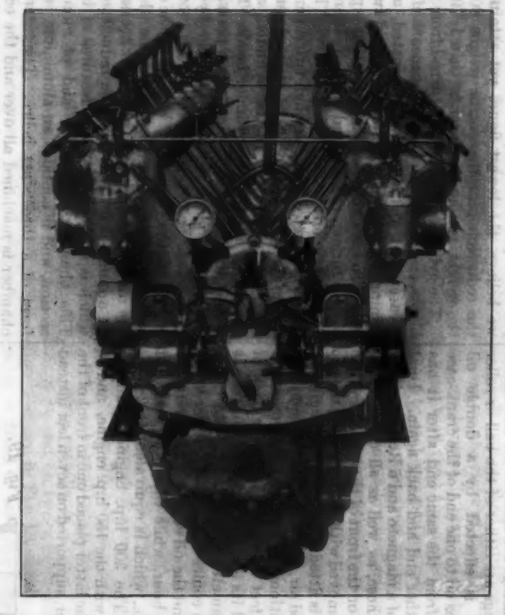


FIG. 21.

is 498 lb., or 2·16 lb. per horse-power, and its petrol consumption comes out at ·7 pint per horse-power hour; the oil consumption is ·078 pint per horse-power hour. They also show 11-cylinder and 9-cylinder Clerget engines, which are rated at 200 h.p. and 140 h.p., respectively. In the former the cylinders are 120 mm. in diameter and the stroke is 190 mm., while the average speed is 1,300 r.p.m. and the average efficient horse-power 230. The petrol consumption of this engine is the same as that of the B.R. 2, previously mentioned, but the oil consumption is greater, being 0·1 pint per horse-power hour. The weight of the engine complete is 510 lb., which is equivalent to 2·21 lb. per horse-power. The nine-cylinder engine has cylinders 120 mm. in diameter, with a piston stroke of 172 mm.; its average speed is 1,250 r.p.m. and the average efficient horse-power 146. As would be expected both the petrol and oil consumption are rather greater than those of the larger engine, the figures being ·73 pint and ·13 pint per horse-power hour for petrol and oil, respectively. The weight per horse-power is also greater for the smaller engine, being 2·56 lb. Messrs. Gwynne's most recent production in aircraft engines is, however, a rather smaller nine-cylinder Clerget engine rated at 100 h.p., but as we propose to give a fuller account of this engine in a subsequent issue we need make no further reference to it here.

The Sunbeam Motor Car Co., Limited, of Moorfield Works, Wolverhampton, show Sunbeam-Coatalen engines ranging from the 100 h.p. "Dyak" to the "Sikh" engine, which develops from 800 to 900 h.p. All the engines are of the water-cooled type, circulation being effected by a centrifugal pump in each case, and, in general, the materials used for the construction of the corresponding parts are identical in composition. The crankshafts and connecting rods are of nickel-chrome steel, the pistons of aluminium, and in most cases, the cylinders are composed of aluminium castings with steel linings and bronze valve seats; the "Sikh" engines, however, have cylinders composed entirely of steel welded together with their jackets, and, in the firm's "Maori" engines, the cylinder blocks are of cast-iron. In all the engines the valves are of high-chrome steel which withstands high temperatures without distortion, and the valve-gearing is of self-hardening nickel-chrome steel. The crank-cases are of aluminium and lubrication is effected on the dry-base principle by means of pumps of the gear-wheel type. Three oil pumps are fitted to each engine—a scavenger pump which draws oil from the sump and returns it to the tank, a main force pump which supplies oil to the main bearings, and an auxiliary pump which forms part of the main pump and supplies oil, at a low-pressure, to the cam-shaft bearings and all auxiliary bearings Carburettors of the Claudel-Hobson diffuser type, the principle of which has been explained above in connection with the Napier engine, are employed, and ignition is effected by high-tension magnetos; two plugs per cylinder are fitted on all engines except the Sikh type, which have four plugs per cylinder. The "Dyak" engine has six vertical cylinders cast *en bloc*, the cylinder diameter being 120 mm., and the piston stroke 130 mm.; its normal speed is 1,200 revolutions per minute. The weight of the engine complete, but without water, fuel, oil or hand starter gear, is 399 lb., which is practically 4 lb. per horse-power, and the fuel consumption, in normal working is, ·54 pint per brake horse-power hour. This engine has been designed for use on small airships in which reliability and economy are the most important *desiderata*, but it can also be used on aeroplanes. The "Arab" engine, also shown, is, generally speaking, similar in design to the "Dyak" engine, but is of the Vee type and has two groups of four cylinders set on the crank-case with an angle of 90 deg. between them. The engine develops 200 h.p. at 1,600 revolutions per minute, and its weight, in the same condition as specified above for the Dyak engine, is 517 lb. This gives a weight of 2·59 lb. per horse-power for an output of 200 h.p. The "Arab" engines, which drive the propeller directly, are suitable for use on high-speed aeroplanes. The "Maori" engine exhibited is that used on H.M. Airship R. 34, but as we have already illustrated and described this engine very fully on page 504 of our last volume, we must refer our readers to that article for an account of this particular engine, merely stating here that it is of the 12-cylinder Vee type and develops 275 h.p. The next exhibit in order of magnitude of power developed is the 300 h.p. "Manitou" engine, which is suitable for aviation work of all kinds, including aeroplanes and seaplanes, as well as for large and small airships. These engines have 12 cylinders cast in blocks of three, and arranged on the crank-case in two rows inclined to each other at an angle of 60 deg. The cylinders are of 110 mm. bore and the piston stroke is 135 mm. The normal speed of the engine is 2,000 revolutions per minute, but the propeller is driven through a reduction-gear with a ratio of 1·57 to 1, so that it runs at 1,270 revolutions per minute. The weight of the engine is 845 lb., or 2·82 lb. per horse-power, and its fuel consumption is the same as that given above for the "Dyak"

engine, viz., ·54 pint per brake horse-power hour. We now come to the "Sikh" engines, two of which are exhibited—one a six-cylinder vertical model developing 400–450 h.p. and the other a 12-cylinder Vee-type engine with an output twice as great. Half-tone engravings of the latter engine are given in Figs. 20 and 21 on page 108. In this engine, which is suitable for airships or large aeroplanes and seaplanes, the 12 separate cylinders are of steel, machined all over, the bore being 180 mm. and the piston stroke 210 mm. They are mounted on the crank-case in two rows of six each with an angle of 60 deg. between them, and any one can be easily removed without affecting the timing of the engine. Three inlet and three exhaust valves, of the overhead type, are provided for each cylinder, the valves being actuated by push-rods and rockers from a single central camshaft placed in the fork of the Vee and driven by gearing from the crankshaft. The general arrangement of the valves and the valve operating mechanism can easily be followed by examining the engravings, Figs. 20 and 21, but it should be mentioned that the camshaft can be withdrawn clear of the engine by merely removing the cover shown immediately below the oil-pressure gauges in Fig. 21. The crankshaft runs in eight die-cast white-metal bearings lubricated as mentioned above when dealing with the engines generally. Its normal speed, when developing 850 h.p., is 1,400 revolutions per minute, but the propeller is driven through spur reduction gearing at 920 revolutions per minute. Four 12-cylinder magnetos are provided, driven by skew gearing and fitted with vernier type couplings, which permit of very fine adjustment. The weight of the engine is 1,952 lb. complete, but without fuel, oil or water, so that the weight per horse-power is 2·3 lb. when developing 850 h.p. In the 6-cylinder 400-450 h.p. engine the design of the cylinders, and the arrangement of the valve and valve-operating gear, is, generally, similar to that of the 12-cylinder engine, but, in the former, the reduction-gear for the propeller shaft is omitted and the normal speed of both crankshaft and propeller is 1,400 revolutions per minute. The smaller engine is particularly suitable for airship work, for which purpose it has been specially designed. The Sunbeam exhibit is excellent in every way and our only unfavourable comment on it is quite a minor point, and one which applies equally to several other engine makers. It is that we question the desirability of retaining a "fancy" name for each design. The practice was introduced during the war, we believe, for the purpose of enabling conversation and correspondence relating to the various engines to be conducted without conveying much information to the uninitiated. The need for secrecy having now ceased to exist we think the fancy names might now be dropped, and that an engine would be sufficiently distinguished by giving only its horse-power and maker's name. At least one maker has already adopted this course, the engine described above as the 450 h.p. Napier engine, being originally known as the "Lion" engine.

We reproduce on page 118 photographs of two engines shown on the stand of Messrs. Rolls-Royce, Limited, 14 and 15, Conduit-street, London, W. 1. The larger engine, Fig. 22, is the latest development in aero-engine design, and is being manufactured at the request of the Government to supply the demand for a reliable engine of high power suitable for use on the large and heavy machines now contemplated. This engine, which is known as the "Condor," is of the Vee type with 12 cylinders developing a total of 600 h.p. Technical data of the engine would, of course, be extremely interesting to engineers, but unfortunately they are not available for publication. The firm also show their 360 h.p. "Eagle" engine with which several epoch-making flights have been achieved. Of these it is only necessary to mention the Atlantic flight and the flight from England to Australia, both of which were made in Vickers-Vimy aeroplanes; they were both remarkable testimonials to the reliability of the Rolls Eagle engine. Of the Falcon engine, also exhibited by the firm, less has been heard by the public, although the engine is well known in the service, since, during the war, nearly all the Bristol Fighters used it—1,364 out of 1,524 to be exact, were equipped with Falcon engines. These engines are of the 12-cylinder V-type and develop 275 h.p. The smallest Rolls-Royce aero engine made is known as the "Hawk," a number of which were installed on airships engaged on coast defence and submarine spotting work from the commencement of 1918 to the termination of hostilities. This engine, which is illustrated in Fig. 23 on page 118, is of the 6-cylinder vertical type and it develops 100 h.p. Several flights of exceptional duration were accomplished with it, one flight extending over 50 hours 55 minutes.

A very interesting exhibit shown is the Zeitlin variable-stroke engine, but we must defer our account of this and of the remaining exhibits of materials and accessories, to our next issue. The exhibition closed on Tuesday last.

(To be continued.)

TUNGSTEN AND THE COOLIDGE X-RAY BULBS.

ENGINEERS will hardly have regretted that Dr. W. D. Coolidge, of Schenectady, when addressing the Röntgen Society on July 15, did not make X-rays as applied to medical science his particular subject as he had intended. His story began with the manufacture of ductile tungsten, and as he took up the thread, where others generally leave it, i.e., at the reduction of the tungstate to a fine metallic powder, his two hours' talk, from 9 to 11 p.m. kept his hearers deeply interested in matters, the elucidation of which they had perhaps not attributed to the inventor of the Coolidge X-ray bulb. Dr. Coolidge himself, we should say, spoke of the X-ray "tube." It is the almost universal custom, regrettable nevertheless, for we have enough "tubes" otherwise, and the term tube certainly did not originally indicate some apparatus contained in a bulbular enclosure.

In the research laboratory of the General Electric Company at Schenectady, tungsten is produced as elsewhere mainly from wolframite, which is a double tungstate of iron and manganese and thus a natural compound of the iron tungstate ferberite, $FeWO_4$, and the manganese tungstate hübnerite, $Mn\,WO_4$. All tungsten ores are associated with other ores and contain many impurities in addition. They are fused with soda to obtain the soluble sodium tungstate, known in Nature as scheelite, from which the yellow acid trioxide, WO_3, is precipitated by hydrochloric acid; this oxide is then reduced by means of hydrogen, and there the description generally ends.* The purification has to be completed on the trioxide; the metal, as first obtained, is very brittle, and as it melts above 3,000 deg. C.—having probably the highest melting-point as well as the lowest vapour pressure of all the metals—it cannot be cast in crucibles, for all fire clays would melt or vaporise before the tungsten, and if we could get an ingot, we could hardly work it. At Schenectady, Mr. Coolidge stated, the oxide is reduced in porcelain tubes wound with platinum. A tube taking a charge of 1 lb. of oxide requires 400 dollars worth of platinum, which became a serious matter during the war. The fineness of the powder and the rate of feed of the purified hydrogen and other features are important factors, which were determined by experiments in hundreds of furnaces. The temperature is slowly raised in eight hours to a definite maximum, and the hydrogen flow is maintained during cooling. The metallic powder obtained is compressed in steel moulds without any binding agent.

It does not appear that thoria is added to the tungsten at Schenectady. We referred to this practice and to the production of very long crystals in the tungsten wire in our issue of August 31, 1917. The metal sticks are too weak to be picked up; they are delivered on molybdenum slabs and fired with these at 1,600 deg. C. in porcelain tubes. The square rods shrink and harden sufficiently to be clamped between heavy water-cooled copper jaws so that direct currents of 10,000 amperes at 100 volts can be sent through the vertical rod; to allow for the contraction, the lower jaws float on mercury, and a hood is lowered over the devices. The heating can thus take place in a hydrogen atmosphere. Dr. Coolidge showed one of these bars, originally about 1 in. square; it was shrunk to ⅜ in. and also somewhat twisted (probably by the asymmetric magnetic field), dull whitish grey, and would break if dropped, he said. The bar is afterwards swaged, again in hydrogen-filled furnaces, between hammers which are rotating pairs of steel dies, each pair reducing the diameter up to 10 per cent., until the rod thickness is reduced to that of a lead pencil. These rods are finally drawn through diamond dies, both wire and die being hot, to the finest almost invisible wire; the density of the compact tungsten is 19·7. Rods are also rolled out hot into flat bars. Any crack is fatal, as welding is impossible.

So far the metallurgical processes had been worked out for the lamp industry. For the X-ray tubes, discs (buttons) were punched out of the bars, heated by the oxy-hydrogen flame, to serve as bulb targets, and there trouble arose about the soldering of the button to or into the stout copper electrode. This was first accomplished by depositing a film of electrolytic copper on the tungsten button, soldering this film in hydrogen to sheet iron and silver-soldering the iron to the electrode lump of copper. But the thermal contact was imperfect and the tungsten was apt to crack, copper then fused into the crack and evaporating spoiled the bulb. They found subsequently that tungsten and copper could directly be soldered if well cleaned of all oxide by the aid of boron carbide or suboxide. The process is carried out in a graphite crucible; the button is placed on the slanting face of a piece of graphite and held in position by two molybdenum pins. The copper is rested on the button, and the whole heated in a vacuum furnace until the copper fuses; the pins remain in the target. The targets thus obtained proved superior to platinum targets. Massive tungsten targets are produced by grinding the stout metal bars with carborundum wheels and breaking off the part.

In his further remarks Dr. Coolidge referred to the researches which led to the substitution of the high vacuum bulb with specially-heated tungsten spiral to generate a stream of electrons, for the old gas-tube in which the positive ions of the residual gas bombard the cathode. Of his own share in this work Dr. Coolidge did not speak at all. It was always "we," never "I," and the only one of his colleagues whom he singled out was Irving Langmuir. The latter observed that in the presence of nitrogen and oxygen—even of inert gases, in fact—tungsten is volatilised and driven with the gas into the glass of the bulb, and he developed the Gaede molecular mercury pump for the high evacuation of the bulb. Langmuir also found that the electron-emission from hot tungsten is very variable in the presence of any gases. But Coolidge himself studied and developed the bulb which justly bears his name. Having learnt a great deal from the behaviour of his "crankiest" gas bulb, containing two entirely equal electrodes both of solid tungsten, which would only run when the anode was hot, and would not run at all when the vacuum was high, he placed a specially heated-spiral (a kind of Edison-Wehnelt cathode) as electron-generator behind the perforated cathode proper, and he studied the effects of various constructions and dispositions of his electrodes and bulbs with the aid of a Campbell-Swinton pinhole camera. This is a lead box enclosing the photographic plate; a hole, 0·03 in. in diameter is made in the front wall, before which the bulb is placed, so that every radiating part photographs itself. They found that the whole cathode, as well as the internal glass wall, was radiating, and not only the focal spot, though that spot fortunately radiates nine times as strongly as any other part, and that it was possible to deflect the electrons by electrostatic repulsion so as to concentrate the radiation. Dr. Coolidge showed by many slides that only with over-exposure the definition of the radiographs should suffer from this cause, and it was very interesting to see how he had investigated these problems by placing perforated hoods of molybdenum, or diaphragm screens of molybdenum over and near the electrodes, and by fitting a readjustable focussing device over the

* For articles on the Tungsten Works at Widnes, Tungsten Alloys and Tungsten Steels, see ENGINEERING, 1917, vol. civ, pages 214, 232, 434, 567 and 697.

cathode changed its position by shaking the bulb. As regards troubles of the bulb-maker, Dr. Coolidge remarked that before the war the bulbs had come from Germany. When the war deprived them of their glass blowers they devised moulding machinery working with rotating chucks and compressed air. In driving the occluded gases out of the metal parts they observed that one hour's pumping was saved by first firing all the metal parts in a quartz-tube vacuum furnace, even if the metal were afterwards to lie in the air for days and weeks. Exhaustion is effected by means of liquid air and of a mercury vapour pump working in series with three rough pumps, the whole vessel being inside an oven at the highest temperature that the glass will bear without collapsing. The liquid air cost them as much as milk, the breakage of the vacuum flask a great deal more. While the bulb is still in the oven a lead hood is dropped over the whole so that the operator can test the bulb under rays without risk to himself, with the anode hot, on a 10-in. spark circuit. Some of the new forms of tubes which Dr. Coolidge exhibited almost deserved their name of tubes, the bulbular expansion being only 2 in. or less in diameter. The slightly brownish very stout glass—apart from the window for the rays—contains 55 per cent. of lead and is almost impermeable to the rays. A new portable outfit weighs 125 lb. and contains bulb, stand and rotary transformer in one box. Noteworthy are also the novel oil-immersed bulbs, all enclosed in a hermetically-sealed metal case which is earthed and provided with air chambers for the oil expansion. A final remark by Dr. Coolidge rather puts a damper on this record of successes. It has more or less been believed that a really constant potential would give us the much desired homogeneous X-rays all of the same wave-lengths; the recent researches of Falk do not confirm this assumption.

A few words in conclusion on the research laboratory at Schenectady. The laboratory was started in 1892, Dr. Coolidge said, by Dr. W. R. Whitney, who was himself chemist, physicist, glass blower and mechanician. At present 250 workers, comprising sixty college-trained men, had five stories of a big seven-story building at their disposal. There was little system in the work, and a good deal of freedom. One type of men might be said to think out the plan; the others tried what they thought of; as a rule a man did not get what he was after, but he got something, and every man might learn what the others were doing. It was not a closed-compartment system in which one man alone knew what was going on.

RECENT EXCAVATOR PRACTICE.*

By F. H. Livens and W. Barnes, of Lincoln, Members.

Much progress has been made with the steam excavator, commonly known as the steam navvy, since the last meeting of this Institution at Lincoln, in 1885, when a paper was read on the "Dunbar and Ruston Steam Navvy." Up to a comparatively recent date, contractors had practically a monopoly in the use of these machines for public works such as railways, canals, and docks, but now more excavators are used in open mines and quarries, in more or less permanent situations, than for contract work. The change is due partly to the difficulties of the quarry owner as regards labour and the necessity for keeping costs down under present-day competition, but also to the introduction of machines more applicable to his special working conditions.

It is the purpose of this paper to illustrate and describe some of the most interesting machines introduced within the last eight or ten years. No amount of descriptive matter can, however, give as good an idea of the possibilities of these machines as labour-savers and of the ease and speed with which they can be handled, as the inspection of them in actual work.

The original steam navvy, which was capable of swinging or slewing its excavating gear through a little more than half a circle, has been now displaced to a large extent by the full circle machine, commonly known as the steam-crane navvy, and developments of this latter type are what the quarry owner and general user find so useful for their work.

The size of machine most suitable for various workings is governed chiefly by :—

(a) The nature of the material, and

(b) The output required per day.

The former will determine the minimum cutting effort to be used. For example :—

4 tons to 6 tons is suitable for material up to clay of medium hardness.

8 tons to 10 tons is suitable for stiff clay.

12 tons to 20 tons is suitable for boulder clay.

20 tons to 30 tons is suitable for heavier material, such as limestone and heavy iron-ore.

The output depends also upon the size of the bucket, which again is governed by the nature of the material to be excavated; thus a machine having 6 tons cutting effort is most efficient when fitted with a bucket of ¾ to 1 cubic yard capacity; if 12 tons, then the bucket should hold from 1¼ to 2 cubic yards; and if 20 tons, from 2½ to 3½ cubic yards, to give approximate examples.

The machine shown in Fig. 1 and Fig. 2 is the type and size of machines in most general use, and is also interesting from the modifications which can be made in it to meet various conditions of working. Its weight is 55 tons net or 62 tons in working order. With the length of jib shown, the machine has sufficient stability for 20 tons cutting effort on the bucket teeth, or, if used as a crane, it will lift a load of 20 tons.

It is supplied with a bucket of 2¾ or 3½ cubic yards capacity, having a renewable mild steel lip-plate carrying steel teeth with renewable points of manganese steel. The main frame has the travelling gear on the underside, whilst the top face or platform carries a combined gear-ring and roller path, upon which the whole upper structure and excavating gear revolves. Two sets of travelling wheels are fitted, one set to standard gauge, usually 4 ft. 8½ in., for use in moving the machine any considerable distance on a railway track; the other, a broad gauge set to carry the machine when excavating. Rollers on the underside of the bedplate support it upon the roller path on the main frame, whilst on it are mounted the necessary engines and gearing for digging slewing, and travelling. The front portion of the bedplate carries the excavating gear, comprising the jib, bucket arm, and bucket. The bucket arm is fitted with long racks gearing into pinions driven from a set of small, self-contained engines fixed on the jib, which vary the cutting or discharging radius of the bucket, the bucket arm being racked in or out as desired.

The digging motion is operated by a wire rope on a hoisting drum of a more or less conventional type driven through a friction clutch, actuated by a steam cylinder for easy and quick operating. The drum is loose upon the drum-shaft and, when free of the clutch, is under the driver's control by means of a foot brake.

The slewing motion is either driven from the main engines used for hoisting, through a set of reversing friction clutches, and the usual gearing, terminating in the gear-ring on the main frame, or by a separate set of engines which is a duplicate of those on the jib.

The travelling motion is taken off the main engines through a train of gearing connected to bevel gears at the top of the centre post, the power being transmitted from these by a vertical shaft through the centre post to the gearing under the main frame.

The complete cycle of operation is as follows :—At the commencement, the bucket hangs in a more or less vertical position, with the teeth resting upon the ground immediately opposite the "face" of the material to be removed (shown in position A, Fig. 3). The driver starts up the engines, and throws in the hoisting clutch. The bucket is then dragged forward and upward into the face, and at the same time thrust out by means of the racks along the bucket arms until the required depth of cut is obtained, the action being almost like putting the feed on a machine tool. With one hand on the control lever of the main engines and the other on the control lever of the racking engines, the driver regulates the motion of the bucket as it is hoisted upwards towards the jib head, the path of cut being an arc struck from the suspension point of the bucket-arm upon the jib. By operating the hoisting and racking motions together, the driver can so control the depth of cut that, providing the material is of a uniform nature, an equal thickness of cut can be taken from the bottom to the top, and the bucket can be filled completely as the top of the cut is reached, as shown in position B. He then throws out the hoisting clutch, racks in the bucket clear of the working face to position C, and holds the bucket up on the free drum by means of his brake. As soon as the bucket is clear of the face, the slewing motion is started up and the bucket is swung round over the wagon or dumping point. When he has reached the right position for dumping, he pulls a cord by his side which withdraws a catch on the bucket door, and the excavated contents of the bucket are discharged. The slewing motion is then reversed, and the bucket is swung back towards the point in the face where the next cut is to be taken. By means of the foot-brake the bucket is then lowered to position D for the following cut, and a similar sequence of operations follows. The whole cycle of operations can be performed in from 20 secs. to 60 secs., depending upon the size of the machine, but chiefly upon the length of the jib. In the navvy described, a cycle of operations takes from 25 secs. to 35 secs.

The machine is capable of dealing with from :—

120 cub. yards to 150 cub. yards of ordinary soil or light clay per hour.

100 cub. yards to 120 cub. yards of stiff clay per hour.

60 cub. yards to 100 cub. yards of ironstone per hour.

60 cub. yards to 80 cub. yards of loose limestone per hour.

The following is a fair average of the working costs per cubic yards loaded into wagons :—

	Per hour. s.	d.
One driver	2	0
One cranesman	1	3
One fireman	1	0
Four men around the machine	5	0
3 cwts. to 4 cwts. of coal...	5	6
Oil and stores	0	9
Total ...	15	6

This represents a cost of approximately 1¼d. per cubic yard for the maximum output of easy material and 3d. for the heavy material.

Fig. 1 shows various positions of the bucket. A is the position of the bucket when it is racked in to the minimum discharging point; B is the extreme cutting and discharging radius, whilst C shows the highest point to which the bucket can be hoisted; this indicates the depth of cut which can be taken without undercutting the material. It is evident that there are certain conditions of working which are beyond the possibilities of B and C on the standard machine, but these can be met by increasing the lengths of the jib and bucket-arm, and correspondingly decreasing the cutting effort and the size of the bucket.

The depth of cut should preferably not be greater than the height the bucket-teeth can reach. Anything above this has either to be blown down by explosives, broken down by hand labour, or allowed to take its chance of falling after it has been undercut by the machine. The first and second involve expense coupled with some difficulty and risk, whilst the last may be dangerous to the men working around or to the machine itself.

To cope with extra depth, the machine shown in Fig. 4 is provided with a much longer jib and bucket-arm to enable it to excavate a face 40 ft. deep without undercutting. The "A" framing supporting the jib has been increased in height to reduce the stresses in the jib and jib ties, but otherwise the machine is similar to the one illustrated and described under Figs. 1 and 2.

Another interesting modification is the combined steam navvy and grab, shown in Fig. 5. It is a dual purpose machine, and was designed and built to work in an ironstone quarry from which the amount of ironstone required was only sufficient to keep a steam navvy employed rather less than half its time. Overlaying the ironstone was about 8 ft. of material which had to be taken off before the ironstone could be excavated, and the proposition was that the same machine might be used both to remove the cover or overburden and to dig the ironstone.

The jib of the steam navvy was therefore extended and fitted with a grab to enable it not only to have enough reach to lay bare a sufficient quantity of ironstone, but to discharge the overburden on to the ground from which the ironstone had been removed.

Two hoisting drums are fitted to the main drum shaft, one for use with the steam navvy bucket, and the other for use with the grab. The same hoisting clutch and brake are common to both drums, and they are so arranged that either of the drums can be connected or disconnected at will. When the grab is required to remove the cover, the bucket is fastened back to the underside of the jib and the grabbing drum is connected to the hoisting clutch and brake. After sufficient cover has been removed, as much, in fact, as the machine can reach, the grab is disconnected and the steam navvy drum is engaged. The machine then works as a standard steam navvy and can dig the stone which the grab has uncovered.

Another useful modification is the machine shown in Fig. 6, which has an extended jib and bucket arm to enable the excavated material to be discharged 60 ft. from the centre of the machine as compared with the 32 ft. of the standard machine shown in Fig. 1. This was specially designed for open-worked quarries in which the overburden had to be dumped from the bucket, back on to the ground from which the mineral had been removed. The machine stands upon the mineral, which in the illustration is ironstone, and will excavate ordinary soil or clay at the rate of 25 cub. yards to 50 cub. yards per hour. It is obvious that when the jib is lengthened to the extent described, the cutting effort upon the teeth must be considerably less than in the standard navvy, otherwise the machine will not be stable. The bucket must also be diminished correspondingly in size. Consequently the cutting power is reduced in this instance to 7 tons and the bucket has a capacity of 1¼ cub. yards.

The discharging radius also governs the depth of cover the machine can deal with. This particular machine, with its 60 ft. discharging centres, will deal with from 15 ft. to 20 ft. of cover. If it were required to remove a greater depth than this, a machine with a still longer reach must be used, and if heavier cover than that indicated has to be dealt with, or in larger quantities, a more powerful machine with a larger bucket must be employed. Very large machines of this type are now in operation, weighing upwards of 300 tons in working order, and carrying buckets of 7 cub. yards capacity, capable of dealing with 200 cub. yards to 300 cub. yards of material per hour. Such machines have a discharging radius of 100 ft. They are naturally slower in working than lighter machines, the time taken to make a complete cycle of operations being from 50 secs. to 65 secs. As alternative to the long jib-crane navvy for removing and dumping quarry overburden direct, is an excavator with a normal length of jib, working in conjunction with a transporter, for taking away the excavated material and dumping it, as shown in Fig. 7. The navvy itself is exactly similar to the one described in connection with Figs. 1 and 2, and stands upon mineral.

The transporter travels in the bottom of the quarry and consists of an underframe and tower, supporting a double cantilever track for the wagon or skip. This underframe is fitted with the necessary wheels and travelling gear which enable it to be moved about the quarry under its own power, and on the underframe are the boiler and winding engines for actuating the transporting gear, which are sufficiently large to haul a fully loaded skip up the inclined track at a speed to suit the excavator, and, in addition, supplying the power for travelling. The skip is about 25 per cent. larger than the excavator bucket to avoid spillage. It is fitted with a hinged door similar in principle to the bucket of the digger, but arranged so that it can be opened at

* Paper read before the Institution of Mechanical Engineers at Lincoln, July 20, 1920.

RECENT EXCAVATOR PRACTICE.

Fig. 1. TYPICAL GENERAL PURPOSE CRANE-NAVVY, TOTAL WEIGHT 85 TONS. (See Photo, Fig. 2.)

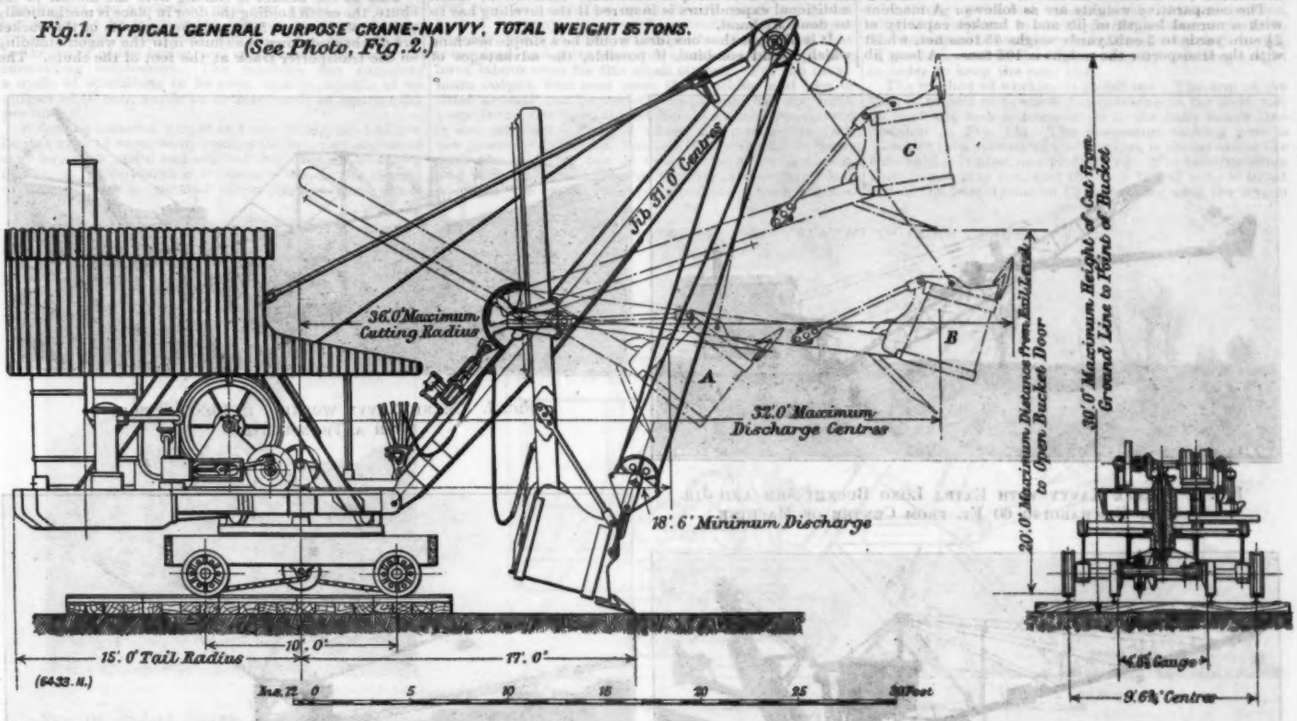
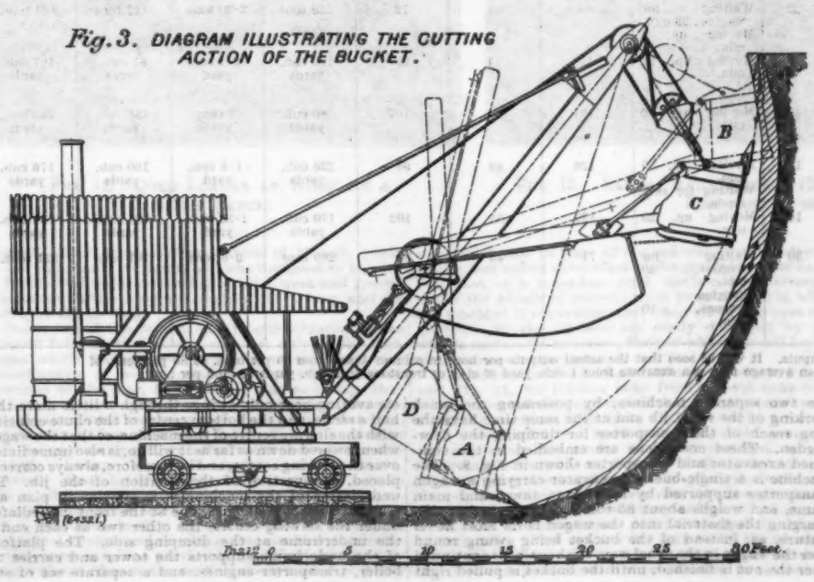


FIG. 2. CRANE NAVVY EXCAVATING IRONSTONE AND LOADING IT DIRECT INTO WAGON.

FIG. 4. CRANE NAVVY WITH LONG JIB TO EXCAVATE A FACE 40 FT. IN HEIGHT.

FIG. 5. COMBINED CRANE NAVVY AND GRAB (SHOWING GRAB IN USE).

Fig. 3. DIAGRAM ILLUSTRATING THE CUTTING ACTION OF THE BUCKET.



any desired point along the transporter track by means of a movable tripping jack, which is traversed by a small hand winch on the transporter, within easy reach of the driver.

The operations are as follows: The excavator takes a cut and discharges the material into the skip standing at the bottom of the track. The transporter engines, controlled by the transporter driver, then haul the loaded skip up the track to the tipping point, where the catch holding the door in place is automatically knocked out, and the contents are discharged. The driver throws out the hoisting clutch and lowers the skip on a free drum under the control of a brake. The adjustable tripping-jack is a useful feature of the machine as the dumping point can be varied so as to leave the surface of the dump approximately level.

The transporter wagon makes a round trip in 25 secs., which is several seconds quicker than the average cycle of operations on the excavator, so as to avoid the latter having to wait for the transporter. It really follows the axiom of the ideal contractor, who should arrange his wagon service so that his steam navvy never waits for empties. An output of 80 cub. yards to 120 cub. yards of ordinary material can be obtained per hour. Compared with a long jib-crane navvy of equal bucket capacity, the plant is capable of a larger output, because of the obviously quicker working speed of the machine with the shorter jib, which reduces the slewing time, and consequently the period taken in making a complete cycle of operations; in other words, the function of the long jib is transferred to a separate machine, the transporter, in which a still longer reach can be obtained. The coal consumption of the two separate machines is also rather less than that of the single machine with equal bucket capacity, as more power is required to slew the latter, because of its increased weight, due to the long jib and the weight required to balance it. The

disadvantages are the extra man employed as driver of the transporter, and the necessity of moving and laying a track for two machines instead of one.

The comparative weights are as follows: A machine with a normal length of jib and a bucket capacity of 2¼ cub. yards to 3 cub. yards weighs 55 tons net, whilst with the transporter the weight is 105 tons. A long jib

formation caused by the discharge from the belt-conveyor, the latter point does not count, but as generally the land has to be put back into cultivation, much additional expenditure is incurred if the levelling has to be done by hand.

It is obvious that one ideal would be a simple machine which would combine, if possible, the advantages of

into the jib and immediately over the top of a chute fitted between the sides of the jib.

Just as the bucket is coming over the mouth of the chute, the catch holding the door in place is mechanically pulled off, the door falls and the contents of the bucket are discharged down the chute into the wagon standing on the transporter track at the foot of the chute. The

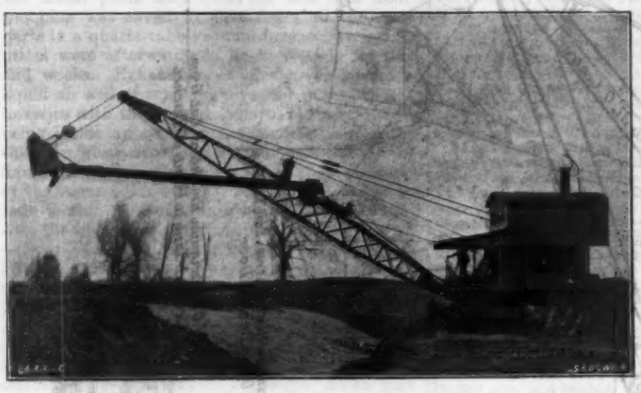


FIG. 6. CRANE NAVVY WITH EXTRA LONG BUCKET-ARM AND JIB. BUCKET DISCHARGING 60 FT. FROM CENTRE OF MACHINE.

FIG. 7. CRANE NAVVY WORKING IN CONJUNCTION WITH A TRANSPORTER.

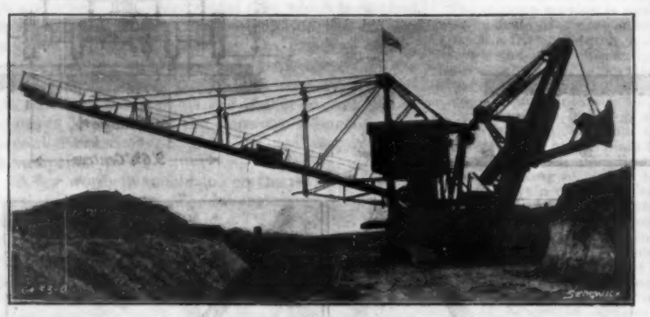


FIG. 8. COMBINED EXCAVATOR AND TRANSPORTER, REMOVING COVER FROM IRONSTONE.

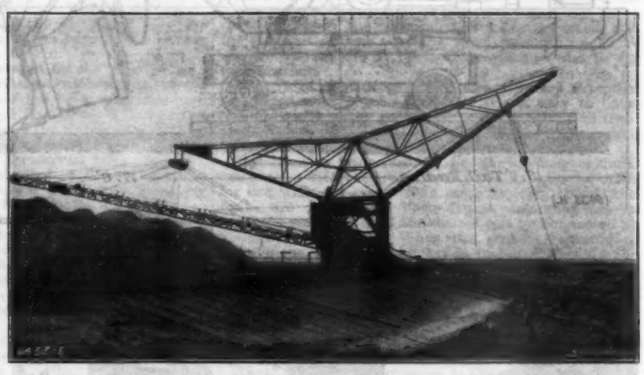


FIG. 9. ENDLESS BUCKET EXCAVATOR COMBINED WITH BELT CONVEYOR.

TABLE I.

Net Weight and Type of Machine.	Material Excavated.	Capacity of Bucket.	Duration of Time Working.	Net Working Time.	Time Lost from :—	Total Number of Cycles of Operation or Cuts.	Average Cuts per Hour Inclusive of Time Lost.	Average Cuts per Hour Exclusive of Time Lost.	Total Amount of Material Excavated.	Average Quantity per Cut.	Average Output per Hour Inclusive of Lost Time.	Average Output per Hour Exclusive of Lost Time.
		cub. yards.	hrs. mins.	hr. mins.							A	B
55 tons crane navvy	Ironstone fairly easy to dig	2·75	2 2	1 18	Waiting for wagons, 33 min. Moving up, 11 min.	100	54	84	254 tons	2·34 tons	125 tons	196 tons
55 tons crane navvy	Heavy ironstone	2·75	1 57	1 22	Waiting for wagons, 29 min. Moving up, 6 min.	99	51	72	228 tons	2·30 tons	117 tons	167 tons.
56 tons long jib crane navvy, 60 ft. discharging centre	Sand	1·50	1 29	1 7	Moving up, 22 min.	110	74	99	120 cub. yards	1·1 cub. yard	81 cub. yards	107 cub. yards
55 tons crane navvy working with transporter	Stiff clay and loam	2·75	2 26	1 47	Moving up, 39 min.	191	79	107	380 cub. yards	2 cub. yards	156 cub. yards	213 cub. yards
49 tons crane navvy working with transporter	Stiff clay and loam	2	1 25	1 17	Moving up, 5 min. Waiting for skip, 3 min.	126	89	98	226 cub. yards	1·8 cub. yard	160 cub. yards	176 cub. yards
85 tons combined excavator and transporter	Stiff clay and sand-stone	2	1 36	1 16	Moving up, 20 min.	129	81	102	170 cub. yards	1·32 cub. yard	106 cub. yards	134 cub. yards
120 tons crane navvy	Very heavy ironstone	4	1 40	50	Waiting for wagons, 40 min. Changing wagons, 10 min.	71	43	85	289 tons	3·8 tons	161 tons	321 tons.

NOTE.—These are ordinary working speeds and outputs. It will be seen that the actual outputs per hour in column A are from 50 per cent. to 85 per cent. of those in column B. Compared with these, an average man can excavate from 1 cub. yard of clay or ironstone to 2 cub. yards of sand per hour.

excavator with the same size bucket and dumping radius of 80 ft. weighs 150 tons. An endless carrying belt is occasionally used in place of the skip, fed from a revolving pan at the foot of the transporter, into which the excavator discharges. The advantage of this arrangement is its lighter weight compared with the track for the skip on account of the distributed load on the belt, as against the concentrated load of the skip. Its disadvantages are the greater maintenance charges—chiefly belt renewals—and the fact that the discharge takes place at one point—the end of the belt. If the ground has not to be left level again, but can remain in the ridge

the two separate machines, by possessing the quick working of the short jib and at the same time have the long reach of the transporter for dumping the overburden. These conditions are embodied in the combined excavator and transporter shown in Fig. 8. The machine is a single-bucket excavator carrying a wagon transporter supported by a common tower and main frame, and weighs about 85 tons. The method of discharging the material into the wagon is its most novel feature, as, instead of the bucket being swung round over the wagon in the usual way, the hoisting is continued after the cut is finished, until the bucket is pulled right

excavating gear only swings through a little more than half a circle, and the bottom centre of the chute coincides with the slewing centre of the machine, so that the wagon, when lowered down as far as it will go, is also immediately over the slewing centre, and is, therefore, always correctly placed, irrespective of the position of the jib. The underframe of the machine is triangular in plan and is fitted with three bogies, one at the front immediately under the slewing centre, the other two at each end of the underframe at the dumping side. The platform of the underframe supports the tower and carries the boiler, transporter engines, and a separate set of self-

contained engines for slewing. The main hoisting or digging engines are mounted upon an upper storey of the tower and above the track of the transporter. The bucket has a capacity of 2 cub. yards. Two men are sufficient to operate the various motions, one the driver of the transporter engines, who also attends to the firing of the boiler, and another who controls the excavating mechanism. The machine can complete a cycle of operations in 20 secs., and is capable of an output of 60 cub. yards to 80 cub. yards of heavy clay per hour.

When the material is light and easy to dig, the endless-bucket type of excavator, feeding on to a belt-conveyor may be a very useful and efficient combination, as shown in Fig. 9. This shows a machine which is the largest of its kind and is operated electrically by three-phase current. It is capable of an output of 80 cub. yards to 150 cub. yards per hour, and was designed to remove 50 ft. of overburden consisting of sand, peat and gravel. The bucket ladder is approximately 100 ft. long, and the conveyor 130 ft. long.

One result of the present-day labour situation is the demand for a small machine, due not only to the high wages which have to be paid, but to the increasing disinclination of men to work with pick and shovel. Previous to the war, hand labour was so cheap, that for small outputs there was little margin to cover the charges incidental to the use of machinery; therefore, comparatively few excavators below 30 tons in weight and 8 tons cutting effort on the teeth were used in this country. Labour conditions have now so altered, however, that brick manufacturers, quarry owners and small contractors must have something more economical than hand work, and a machine of the size and type shown in Fig. 10 meets their requirements. In general design and working the machine is similar to the larger machine previously described, but it only weighs about 10 tons net, and carries a bucket of $\frac{1}{2}$ of a cubic yard capacity, with 5 tons cutting effort upon the teeth.

It will deal with any class of material up to fairly stiff clay, in quantities up to 30 cub. yards per hour; in fact, in many places, such as brickworks, an output of 6 cub. yards to 7 cub. yards per hour may be all that is required, and quite a number of machines are replacing hand labour even for this small output. For the maximum output, two men upon the machine and two or three around can be usefully employed, but for small outputs one man upon the machine and one or two around it are sufficient. Flanged wheels for working on rails are generally preferred, but self-laying tracks do away with the need for one or two of the attendant men, and are finding increasing favour, although adding about 30 per cent. to the price. Road wheels are also sometimes used in place of the rail wheels or self-laying tracks, but unless the surface of the ground is quite hard, like that of a macadam road, timbers are necessary under the wheels to prevent them from sinking in when the machine is excavating and when travelling over soft ground. As the timbers are easily damaged by the wheels and costly to renew, flanged wheels or self-laying tracks are more economical.

A modification of this small machine is shown in Fig. 11 and Fig. 12, for loading coke from a level coke-oven bench. Instead of being fitted with the usual steam navvy bucket, it carries a large fork, 4 ft. 6 in. wide, arranged with tines similar to a hand fork. The racking motion for regulating the stroke of the bucket-arm is also differently arranged, as, instead of the point of suspension being fixed and the working length of the arm varied, as in the case of the steam navvies previously described, the length or working radius of the arm is fixed, and the suspension point is racked in or out horizontally. This enables the fork to be thrust along the bench underneath the coke so as to avoid breaking it. Two independent wire ropes, similar to those used in connection with double rope grabs, pass over the jib head; one of them is connected up to the hoisting drum, the other coils and uncoils on a free drum, and is used for holding up the fork independently of the main rope, when it is required to discharge the coke from the fork. The free drum is rotated in one direction by the lowering of the fork, and in the reverse way by a falling weight in order to keep the rope taut.

The method of working is as follows: The arm of the fork is racked in towards the machine as far as it will go, and the fork is lowered on to the coke bench (see position A, Fig. 11). The horizontal racking gear is then put into operation, and the fork is thrust under the coke intil it is filled (see position B). The hoisting drum then comes into use, and the fork full of coke is lifted out of the heap (position C) and swung over the wagon standing alongside the coke bench. To discharge the coke from the fork, the brake on the free drum, E, is applied, and the main brake released. This allows the fork to tilt downwards and to discharge its contents, as shown in position D.

At the opposite end of the scale to the small crane navvy described, is one shown in Fig. 13, which has 30 tons cutting effort on the teeth and weighs about 120 tons net. It is shown excavating a face of 27 ft. in depth, composed of very thick beds of ironstone, some being over 3 ft. thick, which necessitate the use of explosives to loosen them.

Inner wheels for the standard gauges are not fitted because of the great weight of the machine. Instead of these, the outer wheels have twin treads to enable two rails to be used under each wheel, placed alongside each other, about 6½ in. apart. Mild steel side girders are bolted to each side of the upper bed-plate and are extended to the rear of the machine to carry the boiler, water-tank and ballast box. The boiler is one of the loco-multitubular type, as the steam supply required is beyond what is practicable for the vertical pattern.

FIG. 10. SMALL CRANE NAVVY EXCAVATING CLAY FOR BRICKMAKING

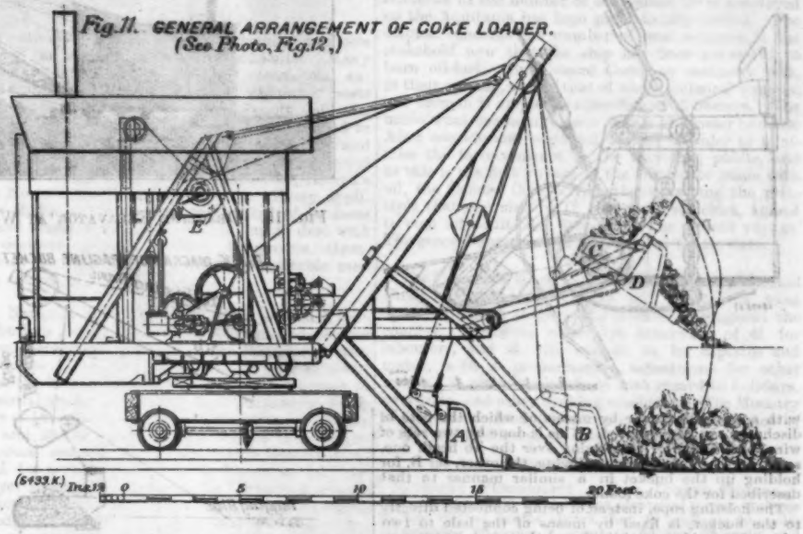


FIG. 11. GENERAL ARRANGEMENT OF COKE LOADER. (See Photo, Fig. 12.)

FIG. 12. COKE LOADER AT WORK ON A COKE BENCH.

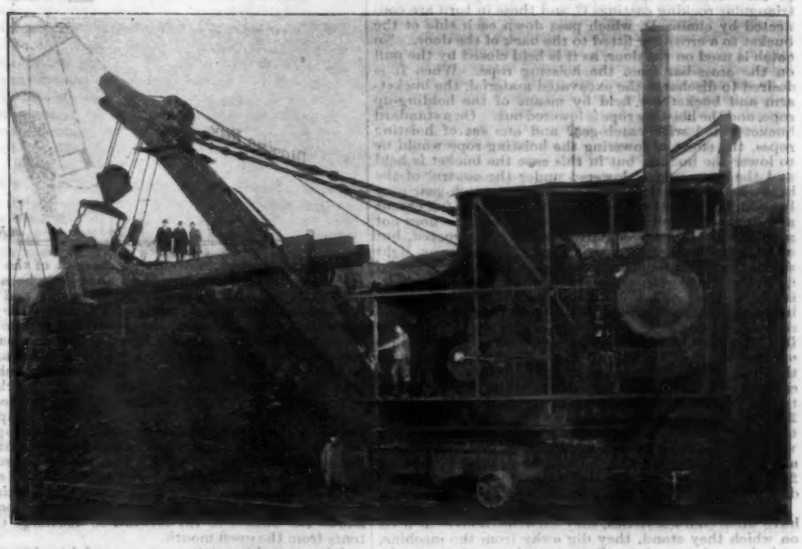
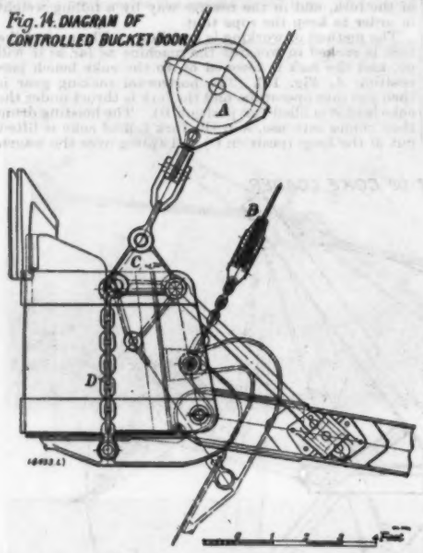


FIG. 13. LARGE CRANE NAVVY, 120 TONS IN WEIGHT. (SIDE SHEETS OF HOUSING REMOVED TO SHOW ENGINES AND GEARING.)

Three sets of double-cylinder engines are fitted to the machine; the largest has cylinders 10 in. by 14 in., and is used for hoisting, whilst two sets have 9-in. by 9-in. cylinders, one on the bedplate for slewing and travelling, and the other mounted on the jib for racking. The bucket has a capacity of 4 cub. yards, and is fitted



with a controlled door by means of which the rate of discharge can be regulated. This is done by two sets of wire ropes (*see* Fig. 14) passing over the jib head, one, set A, for use in hoisting or digging, the other, set B, for holding up the bucket in a similar manner to that described for the coke loader.

The hoisting-rope, instead of being connected directly to the bucket, is fixed by means of the bale to two triangular rocking castings C, and these in turn are connected by chains D, which pass down each side of the bucket to a cross-bar fitted to the back of the door. No catch is used on the door, as it is held closed by the pull on the cross-bar from the hoisting rope. When it is desired to discharge the excavated material, the bucket-arm and bucket are held by means of the holding-up rope, and the hoisting rope is lowered out. On a standard bucket fitted with catch-gear and one set of hoisting ropes, the effect of lowering the hoisting rope would be to lower the bucket, but in this case the bucket is held and the door only is lowered under the control of the brake on the hoisting drum. Ordinary catch-gear may be used, but then the door opens quickly to the full extent and dumps the full load into the wagon. This does not matter when the wagons are specially constructed, but when standard railway companies' wagons or light wagons, as used for hand labour, are used, the effect of dumping 4 tons of ironstone from a height of 4 ft. to 6 ft. is bad for the wagons. The brake gear described above, however, enables the door to be opened gradually and the rate of discharge to be controlled to any extent. In fact, it is possible to discharge a portion of the load into one wagon, close the door again by hoisting, and dump the remainder of the contents into another wagon. A complete cycle of operations can be made in from 30 sec. to 35 sec., and the machine excavates and loads between 250 and 400 tons of ironstone in an hour, with two men on the machine and four or five around it; or comparing it with hand labour, as one man can excavate and load about 1 ton per hour, the machine is capable of replacing 200 to 300 men if a wagon service can be organised to deal with its maximum hourly capacity.

The single-bucket excavators previously described have three characteristics, they excavate above the level on which they stand, they dig away from the machine, and they advance into the excavation as it proceeds. The machine shown in Fig. 15, works in an exactly opposite manner, as it excavates below the level on which it stands, it excavates towards itself, and travels backwards when it has excavated all the material within reach. It is known as a dragline, because the bucket is dragged towards the machine on a flexible rope instead of being guided by a radial arm. It is very useful for drainage work and for situations where the ground is too wet for a machine to stand in the bottom. In construction it is similar in many respects to a crane-navvy; in fact, the latter may be designed so that, by adding an additional drum to the hoisting engines and fitting a longer jib and special bucket, the machine can be converted into a dragline.

The main frame carries the usual travelling gear, which may either be flanged wheels or endless tracks. The upper bedplate carries the hoisting engine and either a separate engine for slewing, or reversing friction clutches driven from the main engines. The hoisting engine is fitted with two drums; one is for digging, the other for lifting the bucket out of the excavation, regulating the depth of cut, and allowing the bucket to swing back for discharging and for another cut. The digging rope, instead of passing over the jib head, as on the crane navvies, passes out at the front of the machine close to the foot of the jib, and is connected to the bucket bale. The lifting or hoisting rope has only to take the weight of the bucket and its contents, and is carried over the head of the jib and attached to the body of the bucket. The jib is of the lattice pattern, much lighter in construction than that of a crane navvy, because in a crane navvy the jib has to take practically the whole of the

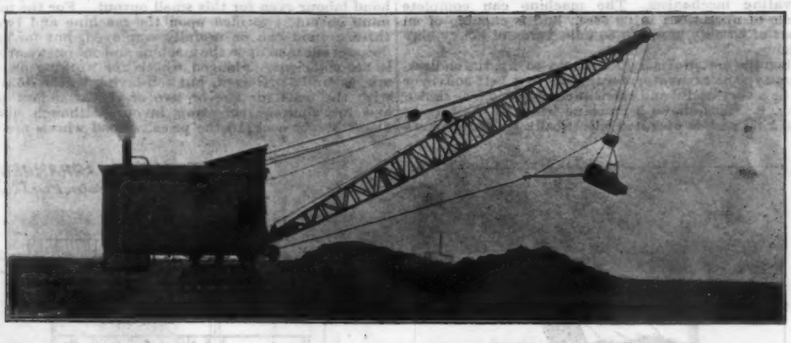
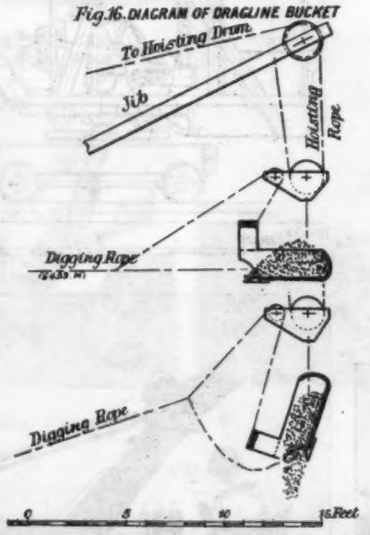


FIG. 15. DRAGLINE EXCAVATOR AT WORK, WITH FULL BUCKET IN POSITION FOR DUMPING.



excavating stresses, not only on account of the digging rope passing over the jib head, but also because the bucket arms, with their attendant slewing and digging stresses, are connected to the jib; the dragline jib has, however, only to take the load due to the lifting rope, together with slewing stresses. As the loading at the jib head is much less than that of a crane navvy of equal size and weight, the jib can be made much longer which is a great advantage for dragline work, as it enables the bucket to be thrown out further to take a deeper and wider cut. The bucket is very simply constructed, being open both at the front and the top. The digging rope is connected to a bale at the front of the bucket, Fig. 16, whilst the hoisting rope is taken to the body or back of the bucket. The contents are discharged by holding the bucket up on the hoisting rope and releasing the tension of the digging rope. This allows the bucket to tilt forward to discharge the contents from the open mouth.

A large working radius is very useful in this machine, and as working height above the rail is not needed, excepting for dumping, the jib has a much flatter angle than in a crane navvy, and in addition is usually fitted with derricking gear for altering the working radius. The angle of the jib varies from 25 deg. to 40 deg. from the horizontal in the case of a dragline, and from 45 deg. to 60 deg. for a crane navvy.

The method of working is as follows: the bucket is lowered out at its extreme radius to the foot of the excavation, the digging drum is put into gear and the bucket is dragged into the material towards the machine, the thickness of the cut being regulated by means of the tension on the hoisting rope. If the cut is correct, the hoisting drum unwinds freely. A thinner cut can be taken by braking the hoisting line. When the bucket is full, the digging clutch is thrown out and the hoisting gear is put in. The bucket is then lifted on the hoisting rope and the digging rope is allowed to run out under the control of the brake so as to swing the bucket towards the front of the jib. The machine is then slewed over the dumping point and the bucket discharged. The bucket can be swung out beyond the jib-head radius to take a larger radius of cut by drawing in the empty bucket on the digging line, and then letting it run out as freely and as fast as it can, so that it swings beyond the jib-head.

The speed of operation is approximately equal to that of a crane navvy of the same weight, the size of bucket in proportion to the cutting pressure also being similar.

It may be interesting to give some comparative working information of some of the machines illustrated and described, and for that reason some of them have been accurately timed and tabulated in the table given on page 112.

EMPIRE MOTOR FUELS.—Mr. Walter Long, M.P., has informed Mr. E. S. Shrapnell-Smith, C.B.E., Chairman of the Empire Motor Fuels Committee of the Imperial Motor Transport Council, that it will afford him pleasure to be Chairman of the Motor Fuels Section of the Council's Conference on October 18 next, when the reports of the Engineering and Denaturation Sub-Committees will be received, and various papers will be contributed. Sir George Beilby, F.R.S., Sir George Goodwin, K.C.B., and Sir John Cadman, K.C.M.G., have similarly intimated their pleasure in becoming Vice-Chairmen of the Conference, to support Mr. Walter Long. There will be an evening session at the Royal Automobile Club on October 18, when Professor H. B. Dixon, F.R.S., will give a lecture and demonstrate certain experiments in relation to power alcohol.

THE LATE MR. RICHARD RAMAGE.—We regret to have to announce the death, which occurred on the 16th inst., at The Hawthorns, Leith, of Mr. Richard Ramage, a well-known Scottish shipbuilder. Mr. Ramage was in his 87th year. He received his training in the yard of Messrs. Barclay, Curle & Co., and was for many years subsequently with Messrs. William Denny and Brothers, Dumbarton, ultimately occupying the position of manager of their works. In the year 1877, in connection with Mr. Ferguson, a friend of his who had been trained together with him, he started a shipbuilding business at Leith, under the name of Ramage & Ferguson. Their yard rapidly became an important one; in fact, the activity and thoroughness displayed by both partners soon led their firm to be considered the premier shipbuilding firm on the East Coast of Scotland. Their first vessel was the steamer Shamrock I, built for local shipowners, since when they have constructed a large number of cargo and passenger steamers, and steam yachts, in which latter type of vessel they acquired a well-merited reputation. Mr. Ramage played a prominent part in both the industrial and the public life of Leith; he was at one time a member of the Leith Town Council, and also served on the Dock Commission and on the School Board.

BRITISH EMPIRE EXHIBITION.—It is proposed to hold in London, in 1923, an exhibition representative of the industries and resources of the British Empire. Its objects are to foster Inter-Imperial interests, from both a commercial and a political standpoint, and to demonstrate the natural resources of the territories of the Empire and the inventive and manufacturing energy of its peoples. The exhibition will be privately organised but is receiving official recognition and support. H.M. the King has given it his patronage, and H.R.H. the Prince of Wales has consented to act as President of the General Committee. The Government propose to ask Parliament to sanction their participation in the guarantee fund to the extent of £100,000, subject to conditions to be approved by the Treasury, on the condition that an additional sum of £500,000, is secured from other sources. As a further condition of this participation the Board of Trade have obtained an undertaking from the Executive Council whereby the Board shall have the right to approve the choice of a general manager of the Exhibition; shall satisfy themselves that the Executive Council is properly constituted; and shall approve all regulations in connection with the exhibition such as those affecting the participation of the various parts of the Empire and the entry of British exhibitors. The Board would also be represented officially on the Executive Council. The Board are, therefore, in a position to take all possible steps for securing that the exhibition is conducted with a proper regard for economy and in such a manner as to ensure its success. The exhibition is not being organised for profit; any surplus which may be available at its close will be devoted to some public or charitable object.

INDUSTRIAL NOTES.

WE deal on another page of the present issue with the award of the Industrial Court in the matter of the claims of the unions connected with the engineering, foundry and shipbuilding trades for an advance of 6*d.* per hour. The Court found that the claims had not been established.

In the report for the present month issued by the United Society of Boiler Makers, and Iron and Steel Shipbuilders, the General Secretary, Mr. J. Hill, says that "the principal unions are of opinion that they can negotiate their wages claims more satisfactorily direct with the employers, and without the aid of a Court, or even of an independent chairman. We all along have held quite a different opinion. Our agreements with employers, with their long-drawn-out procedure and delays, and with the proviso that no strike nor even the curtailment of overtime can take place until the whole of the weary procedure of an almost endless succession of abortive conferences have been held, have never been satisfactory. Our 1909 agreement was a millstone round our necks, and our members have not yet forgotten how, in 1910, the employers pushed us into the lock-out and almost drowned us. The argument against our present arbitration proceedings is that it is almost compulsory arbitration, and awards are unsatisfactory. The best answer to this charge is that, whilst we have had the usual protests about the inadequacy of the awards, there has been a general recognition by the workers concerned that no organised body of employers ever would or ever did give anything equalling the awards of these National Courts. Again, with a neutral Court, there is a much freer atmosphere than with an employer in the chair. Instead of the secret conferences with the employers under which the executives pledged themselves not to show the shorthand notes to their own members, I prefer even an opener Court than now, sitting in the towns affected, and with the press and the public in attendance."

The seamen have appealed to the miners to increase the coal output with a view to decrease the unemployment in the South Wales ports. In this connection, Mr. M. Tearle, secretary of the Cardiff branch of the National Seamen's and Firemen's Union, has stated that the present position of unemployment of seamen would end if the coal miners gave an increased output. He suggested that the miners should be asked to work an eight-hour day instead of a seven-hour one as at present until the country was in a better financial position. They could return to shorter hours when things were more prosperous. He did not suggest that they should work this extra hour without extra remuneration. In this matter he was fighting for the seamen represented, and not against the miners as such. He could not believe the coal miners realised the misery they were bringing to seamen and other workers by following the dictates of a few extremists who were unwilling to give any consideration to the needs of other workers, or to the needs of the country.

Speaking last week at the annual general meeting of the General Electric Company, Limited, Mr. H. Hirst said he would rather see the State encourage profits and tax companies even 15 per cent. or more, by a profits tax than continue to allow industry to grope in the uncertainty of an Excess Profits tax. He could not give the shareholders any information as to how much of the "carry forward" may have to be given up. The State issued all kinds of statistics, admitted that life was dearer by 115 per cent. to 150 per cent., encouraged higher wages, but forgot, or ignored, the vital fact that to those thrifty people who denied themselves many of the pleasures of life, whose savings represented the accumulation of the wealth of the country, and stood at the back of productive industry—the company's shareholders—that to those people 10 per cent. to-day was of less value than 5 per cent. before the war. Taking another view of this pernicious tax, he added that if the Government borrowed at 6 per cent., was the extra 4 per cent. which went to the shareholders, who in the company on an average had received 10 per cent., sufficient for all their risks? Again, did people realise that, in order to earn this extra 4 per cent., the company had been the means of spending two million pounds in wages and salaries, and that they had built up industries which kept capital in this country which otherwise would have to flow abroad? If the workers only realised that the aim to be self-reliant and the desire to earn profits were the mainsprings securing them continued employment, they would listen with less favour to those well-meaning but misguided idealists who disdained profits and believed that the distribution of all capital would solve all social troubles. They would soon find out—as they found out in Hungary—that capital by itself, unless made to work, was a will-o'-the-wisp. If the workers only knew how little the total profit which flowed into shareholders' pockets was compared to the amount of wages paid, they would realise that nothing but increased production would help them to higher wages, cheaper cost of living, and better social conditions. In the company's balance-sheet the ratio of wages to dividends was about 8 to 1. If commodities are produced cheaply so that the greatest number of people can avail themselves of them, there will be continuous employment. If, on the other hand, prices are allowed to soar higher and higher, only the few can buy, and the world's demand will be so curtailed that there will be over-production, factories and works will have to shut down, and wages will largely cease.

There are still great numbers of demobilised officers and men in need of civil appointments. Many of these have already had overseas commercial experience and others are desirous of obtaining posts abroad. The Appointments Department of the Ministry of Labour has on its books men qualified to fill any position in business or professional life, and firms requiring additions to staff are urgently requested to send particulars to the District Inspector, Horrex's Hotel, Norfolk Street, Strand, W.C. 2. Every applicant is thoroughly examined by a board of business men, and a special panel has been set up to deal with those desirous of going abroad. Employers, therefore, may be confident that none but suitable men will be submitted.

The National Insurance Act, 1911, provided that contributions should be payable for employed persons between the ages of 16 and 70. No change has been made by the Act of 1920 (referred to on page 47, *ante*) in these age limits, and employers are still required to pay contributions as soon as their employees reach the age of 16. In the case of workers between the ages of 16 and 18 the employer may deduct from wages the normal amount of the employee's contribution, *i.e.*, 5*d.* for a male and 4*d.* for a female worker, the employer paying the remaining 5*d.* Where, however, a worker aged 18 or upwards is not in receipt of board and lodging from the employer, and the rate of remuneration does not exceed 4*s.* for a full working day, the portion of the contribution that may be deducted is less than the normal. It is a penny less if the rate of remuneration is over 3*s.* for a full working day, but where the rate of remuneration is not over 3*s.* for a full day, no deduction may be made from wages. The remuneration limit of 250*l.* a year for compulsory insurance in the case of non-manual workers was fixed not by the recent Act, but by the National Health Insurance Act of last year. The liability of employers to pay contributions for persons affected by that Act, *i.e.*, non-manual workers whose remuneration was over 160*l.* and not over 250*l.* a year, operated from August 15, 1919, the date of passing of the Act, and cards were required to be stamped from that date.

The Executive of the Miners' Federation of Great Britain met the Controller of Coal Mines at the Hotel Windsor on the 15th inst., and placed before him the claims of the Federation referred to in our last issue. The Controller replied that he would consider the matter and submit it to the President of the Board of Trade.

The Coal Association has issued a statement on the subject, establishing that "the money to pay for these concessions is to come from the high export prices, the proceeds from which at the present time go almost entirely into the national Exchequer.

"The inclusion of a demand for a price reduction with that for a wages increase is an astute move to secure public sympathy. But whether public support is forthcoming or not Mr. Smillie has indicated by his recent remarkable utterance on nationalisation that public opinion is now but a secondary consideration where the interests of the miner are involved.

"What is the position with regard to the second point—that of wages? The average wages cost of a ton of coal in 1913 was 6*s.* 10*d.*; to-day the amount paid in wages at the pit on every ton of coal is over 25*s.* 2*d.*, or nearly four times as much as in 1913. This enormous increase is due in the main to the increases in wage rates that have been awarded at various times since the outbreak of war up to the time of the last advance of 20 per cent. as recently as May last, but also in large measure to the reduced rate of output, for the serious side of the problem is that an increase in wages is inevitably accompanied by a reduction in output.

"At the present time there are over 1,200,000 men employed in the mines, as compared with 1,110,000 in 1913, and yet the output of coal is now only at the rate of about 240,000,000 tons per annum as against 287,000,000 in 1913. The output during the past few weeks has been actually less than in the early part of the year, the reduction being apparently of the order of about 50,000 tons per week, or two and a half million tons per year, since the increase of wages took place in May last.

"The published costs of American coal for February was 11*s.* per ton at the pit. This means that in spite of the enormous rail haulage of three or four hundred miles to the coast, the Americans can place coal on board ship for export at a cost of less than 20*s.* per ton. The corresponding cost of placing South Wales coal on board ship in the Bristol Channel ports is 45*s.* per ton."

A dispute which had arisen between the Sailors' and Firemen's Union and the Cunard Company with reference to the number of oil-firemen to be employed on the Aquitania has been provisionally settled. The dispute concerns the number of men required in the stokehold now that the ship has been converted to burn oil-fuel. The Cunard Company maintain that, in their opinion, and in that of their technical experts, one fireman is ample for attending to 12 burners. The union want one man to have charge of a lesser number. After considerable negotiations and in order to minimise the inconvenience to the travelling public, and as this is the first voyage of the ship to be made with oil, the Cunard Company, without waiving the principle that one man to 12 burners is sufficient, agreed to sign on additional firemen for the present voyage. The general question will be settled at a later date.

The Transport Workers' Federation and the National Union of Railwaymen have put forward a joint claim on behalf of the canal workers throughout the country. Minimum wages are demanded of 4*l.* for labourers, and 4*l.* 10*s.* and 4*l.* 5*s.* for captains and mates, with a proportionate adjustment for other grades. A claim is also made with regard to holidays, over-time, and other working conditions. The Ministry of Labour has been asked to convene a conference of employers and unions to discuss the claims.

CURRENT PERIODICITY IN THE UNITED STATES.—An analysis of 60 of the large electrical power systems in the United States shows that 49 generate 60-cycle, 6 generate 25-cycle, 4 generate 60 and 25-cycle, and 1 generates 50-cycle alternating current. There are approximately 4,750,000 kilovolt-amperes of 60 cycle, 1,250,000 kilovolt-amperes of 25-cycle, and 160,000 kilovolt-amperes of 50-cycle generating capacity installed on these systems. If we are going to standardise on a frequency, says *Power*, New York, why not take 60-cycles, since this system predominates to such a large degree, and is probably better suited to general power requirements than any other?

FRENCH COMMERCIAL INTELLIGENCE DEPARTMENT.—A display of French manufactured articles was opened at the offices of the French Commercial Intelligence Department, 153, Queen Victoria-street, E.C. 4, on the 15th inst., by Mr. Perier, Minister Plenipotentiary and Commercial Attaché to the French Embassy, who said that the present display was the sixth, the first having been opened on February 15, 1919, a fact which gave evidence of the progress being made in France in the economic reconstruction of the country. In travelling through France at the present time, Mr. Périer added, one could witness evident signs of her recovery from the agricultural standpoint; he was anxious, however, as to the industrial situation. Owing to the lack of coal, the reconstruction of the French industries would be, unfortunately, a slow process, and he appealed to the Press to acquaint their readers with the needs of both France and this country, with a view to strengthen still further the bonds which had united both since the evil days of 1914. The display, which is to remain open until the 31st inst., contains an interesting variety of articles, among which may be mentioned optical and survey instruments, photographical apparatus, laboratory accessories, &c., as appealing more especially to our readers.

OIL STORAGE, TRANSPORT AND DISTRIBUTION.—In the course of the third very instructive lecture, delivered before the Institution of Petroleum Technologists at the Crystal Palace on July 14, Mr. H. Barringer, M.Inst.C.E., &c., exhibiting an old Chinese print of a junk for carrying fresh water, showed that the Chinese understood the importance of a narrowed trunking to reduce the free surface of the liquid exposed to the motion of the sea. As regards oil fuel on board, he expressed preference for the pressure system, in which the oil was forced under pressure through heaters and discharged very hot into the burners. That system did not require either steam raising nor compressed air plant; forced draught should be used. In coasting work the tank ships were towed and had no propelling power. The Anglo-American Oil Company had built a powerful twin-screw tanker to pull an 18,000-ton oil barge across the Atlantic which had proved successful. Towing cigar-shaped, partly submerged vessels had also been proposed, and similarly submersible floating storage-tanks in port. Interesting slides of tank steamers which had reached port during the war, though torpedoed, were also exhibited. The remaining four lectures of the series will be given on the Wednesdays of September, beginning with Mr. G. Howell's lecture on "Oil Prospecting," on September 1.

NOTES ON NEW BOOKS.

PARTICULARS relating to patents, including the procedure to be followed to obtain them, the fees, the duration of the grant, &c., also conversion tables and other data on electrical matters, testing rules and so forth, tariffs, a legal digest, &c., form the opening handbook section of "*The Blue Book*" which, with the present edition, for 1920, is in its thirty-eighth year of issue. It is edited by *The Electrician* and is published at the price of 25*s.* net by Messrs. Benn Brothers, Limited, 8, Bouverie-street, E.C. 4. The directory portion gives the names of British electrical firms and engineers, their postal and telegraphic addresses and telephone number, the names being in alphabetical order; then follow a directory arranged alphabetically according to the specialities dealt with, and directories of Colonial, Continental and American electrical engineers and concerns.

"No greater problem confronts the British people than that of organising their vast productive resources, of securing the highest returns of which these are capable, and of harmonising the operations and results of industry with the supreme end of our common well-being. That object cannot be fulfilled by the efforts of any one class or interest, and still less is it within the reach of the collective and impersonal State. It has to be worked out by every section of the community attaining to a clear vision of its own responsibility, and by the reconciling sense of reason and justice bringing these single ideals ultimately to a single focus." Such is a statement in the preface of "*The Employer's Year Book*," dated May, 1920, edited by Philip Gee, and issued at 246, Temple Chambers, E.C. 4, at the price of 25*s.* We agree with this statement in its entirety, and for that reason we disagree with the title, since the book appeals to all employees as well as to all employers. It deals under all their aspects with the manifold questions which affect the industries and commerce of the British Empire, and appeals to Labour as well as to Capital. In point of fact, we are convinced that more good would result to the whole community were the book to be read with an open mind by all trade unionists of the realm and its indications and recommendations acted upon by them, than will be the case if it remains simply, what its title seems to imply, an employer's year book. We recommend it therefore to the general public.

The first annual directory, for 1920–21, entitled "*Who's Who in Engineering*," which is edited by John Ed. Sears, C.B.E., M.A., Assoc.M.Inst.C.E., and is published at the price of 25*s.*, by the Compendium Publishing Company, 93 and 94, Chancery-lane, W.C. 2, has now appeared. It gives a biographical notice of a large number of British engineers and scientists. This is followed by a classified list of engineers according to the branch of engineering in which they specialise, a chapter which affords a proof that the efforts of the editor have not met with the response they deserved on the part of members of the various professions which he circularised, since the list in question contains the names of only three agricultural engineers, one colliery engineer, three hydroelectric engineers, and so forth. We hope that many more names will appear in the second and following annual editions. Another chapter in the book is the alphabetical directory of firms, stating their specialities, the date of their foundation, the names of the directors, their war services, &c. The book will be useful also for its index to manufactures, also for the particulars it gives of the engineering institutions and societies, on centres of technical engineering training, trading and research associations, and associations of employers and of employees.

METALLIC ACCESSORIES FOR RADIOTELEGRAPHIC APPARATUS.—In the early days of experiments with high-frequency currents suitable for radiotelegraphy, metallic supports, cases, &c., were avoided as much as possible lest the eddy currents induced in the metals should exercise a damping effect on the apparatus. As the work became more technical, metals could not be kept out, but iron was either barred or provided with screens of copper or other less objectionable metals. It was found that stout plate screens were not required, but that galvanic coatings would do; there were, however, hardly any determinations of the minimum permissible thickness of these coatings. According to experiments made by J. Preuner and L. Pungs, of the Marine Research Laboratory, Kiel (*Deutsche Physikalische Gesellschaft*, 1919, page 594), very thin films will be sufficient. A thickness of an electrolytic copper deposit of 0·03 mm. or 0·04 mm. will practically screen iron in a high-frequency field; zinc deposits must be thicker, but coatings of 0·1 mm. will likewise suffice. The determinations were made with the aid of a calorimeter of unusual capacity, six litres; the specimen was placed in oil in this calorimeter. The temperature of the oil rose by some 3 deg. C. during the experiments, which took about 10 minutes, owing to the heating of the specimen by the eddy currents.

GERMANY'S POST-WAR INDUSTRIAL PROBLEMS.

TO THE EDITOR OF ENGINEERING.

SIR,—There is one point affecting Germany's post-war industrial problem which does not appear to have been brought out in your comments upon the report of the Department of Overseas Trade in the last issue of ENGINEERING, but which requires careful investigation when attempts are made to estimate the recuperative powers of German industry. Germany has lost a large proportion of its unskilled labour, not only as a result of death or mutilation on the battlefield, but more because a huge reservoir has now been closed by the founding of new States like Poland, Czecho-Slovakia, and Jugo-Slavia. I remember visiting a large factory in Aachen in 1909 in order to inspect the manufacture of a fairly large order for railway materials required by a Colonial Government. I was much struck with the fact that the only Germans in the factory were the foremen, and I inquired who the others were. The manager (one of the most capable men I have met, a Cambridge graduate) was perfectly frank and said that they were Poles, Ruthenes, Slovaks, and other "savages" (as he expressed it) from Central Europe. He paid them from 5*s.* to 7*s.* per day, and they constituted 75 per cent. of the labour force of the factory. He added that they had still "wilder" men, whom his company paid less, in the coal and iron mines of Germany, and, he attributed the capacity of Germany to undercut Great Britain in the iron and steel industries to the existence of this cheap and, as compared with negroes and Indians, efficient labour. The proportion of foreign labour to German in some of the mines exceeded 90 per cent.

The source of cheap labour is now completely cut off, and it will take many years for a sufficient number of native Germans to take to mining in order to bring the output of coal to pre-war figures.

I did not pursue the matter at the time, but wonder if the census classification of the population of Germany before the war would enable the above statement to be verified.

Yours faithfully,

July 16, 1920. LUNGAIL.

STANDARDIZATION OF SHAFTING.—The American Engineering Standards Committee has invited the American Society of Mechanical Engineers to act as sponsor for the standardization of shafting, says the *Iron Age*, New York. The Society has already done a considerable amount of work on a set of standard diameters for transmission and machinery shafting. It is proposed that the work, which will be carried out by a sectional committee under the rules of procedure of the A.E.S.C., shall be broadened to include the standardization of the method of determining what diameters of transmission shafting should be used for given loads, the dimensions of shafting keys and keyways, and the setting of dimensional tolerances.

THE SWEDISH SPITZBERGEN COAL COMPANY.—The Swedish Spitzbergen Coalfields, Limited, says *Swedish Expert*, has sent to the Government a petition for a grant of 5,000,000 kr. in return for shares in the company. It is pointed out that, as the Spitzbergen Treaty has now been signed, and as the position of the company at the present moment is such that it is necessary to decide the question of procuring Swedish capital, it has been deemed expedient to submit the question to the Government. It is of the greatest consequence that the projected extension of coal raising may be effected as soon as possible, and that the company may be sure of being able to follow out its work with exclusively Swedish capital. It is stated that the shipments of coal from the Swedish mines on Spitzbergen amounted to 20,000 tons in 1919. During the coming summer it is estimated that about 50,000 tons can be shipped, the main part of which, or 40,000 tons, is to be delivered to the State railways at Narvik. During the past winter 144 persons have spent the winter at the Svea colliery.

MOTOR TRACTORS IN FORMOSA.—Agricultural motor-tractors were first used on sugar plantation work in the early summer of 1919, writes H.M. Acting Consul at Tamsui. At present there appear to be about 20 of such tractors in use in the island. All are of American manufacture and range up to 75 h.p., so far as has been ascertained. They were imported through the medium of a British firm. Two of the sugar companies have more tractors on order, and it is understood that a third is also about to make use of them. Those companies which have tractors already in use appear to be well satisfied with them, and it seems probable that a good number of the other companies will follow suit in the course of time. To give some idea of the opening which may exist for the sale of agricultural tractors, it may be mentioned that the area under sugar-cane in Formosa is, in an average year, about 250,000 acres. There are probably over 30 companies with a capital of not less than 1,000,000 yen each engaged in the sugar industry. The aggregate authorised capital of these companies is over 200,000,000 yen, one-half of which has been called up. One company has an authorised capital of 40,000,000 yen, and three others a capital of 25,000,000 yen each. Nearly all the older-established concerns have been making enormous profits during the past few years, and the present is an excellent opportunity for pushing the sale of modern appliances and machinery. Competition, however, will become increasingly difficult as time goes on.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The trend of business in the engineering and steel trades is on a downward grade. Record prices of basic materials and a marked shortage of essential supplies of semi-finished products, among other principle causes, are now reacting with weakening effect on contract business both at home and abroad. Orders for ship construction, from which Sheffield ordinarily derived large benefit, are being held up because the cost has advanced something like four times on the pre-war price. Two contemplated orders for big ships, which were to have been placed with a local concern, have been cancelled because the cost of production has made it impossible for shipowners to pay for them. Other engineering negotiations of a similar character have fallen through simply on a question of price. The call for marine shafting and constructional steel for shipbuilding purposes is distinctly easier. German shafting is reaching the local market to compete with the Sheffield product. Belgian and American makers are offering bar iron, rolled iron, and steel billets at prices substantially lower than those quoted by local producers. This is inevitably affecting South Yorkshire prices, which, for the first time for many months, show an easier tendency. Marked qualities of bar iron are realising 33*l.* 10*s.* per ton, and inferior sorts 30*l.* per ton. A premium of from 1*l.* to 2*l.* is charged for prompt delivery of the latter. Common irons are not attracting as much attention as they did a month ago. This is attributed partly to the customary slackness prevailing at this time of the year, and partly to the effect of renewed competition from overseas in the semi-finished branches. Steel bars are reported to be offered locally as low as 24*l.* per ton as compared with the recent record maximum of 34*l.* Steel sheets are also slightly easier, though output still falls short of requirements. Steel-making departments, for the most part, are still working at high pressure on contract arrears. Great activity prevails at rolling mills, foundries, and forges. More work is arriving at the railway steel branches, but the gross volume of business is not sufficient to tax the widely extended basis of production. There is a marked diminution in the demand for high-speed steel. Apart from American purchases, overseas requirements are considerably lighter. The market for alloys is accordingly weakening. The continued absence of supplies of vanadium from America is another unfavourable factor. Weak patches are evident in the crucible-steel trade. Several furnaces are working short time. The easing-off noted in the heavy engineering trades is not reflected in the lighter branches. Files, saws, and engineers' small tools are leaving Sheffield on contract account in record quantities. Sufficient orders have been booked by the light casting foundries to ensure two to three months' activity. There is also a very healthy demand for machine knives and implement parts.

South Yorkshire Coal Trade.—Gas companies and railway companies are now, practically stocked against the coming winter's requirements. Collieries are diverting hard coal from railway depôts to furnish merchants with emergency stocks. The whole of the output of industrial fuel is going away promptly on contract account. The house coal section is quiet. The public despite repeated warnings, are still holding off in the expectation of a reduction in prices. Cokes form a strong market, and are not easily obtained. Slacks are a shade easier. Quotations: Best branch handpicked, 37*s.* 2*d.* to 38*s.* 2*d.*; Barnsley best silkstone 37*s.* 2*d.* to 37*s.* 8*d.*; Derbyshire house coal, 32*s.* 8*d.* to 33*s.* 2*d.*; Derbyshire best brights, 35*s.* 2*d.* to 36*s.* 2*d.*; Derbyshire best large nuts, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire small nuts, 31*s.* 8*d.* to 32*s.* 8*d.*; Yorkshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; rough slacks, 28*s.* 2*d.* to 29*s.* 2*d.*; nutty, 27*s.* 2*d.* to 28*s.* 2*d.*; smalls, 23*s.* 2*d.* to 24*s.* 2*d.*

THE CUTLERY INDUSTRY.—The Secretary of the Department of Scientific and Industrial Research announces that the Research Association for the cutlery industry has been approved by the department as complying with the conditions laid down in the Government scheme for the encouragement of industrial research. As the association is to be registered as a non-profit-sharing company the promoters have applied to the Board of Trade for the issue of a licence under Section 20 of the Companies' (Consolidation) Act of 1908. The secretary of the committee engaged in the establishment of this association is Mr. W. H. Bolton, P.O. Box 49, Sheffield.

THE PHYSICS AND CHEMISTRY OF COLLOIDS AND THEIR BEARING ON INDUSTRIAL QUESTIONS.—The Faraday Society and the Physical Society of London are arranging to have a joint symposium and general discussion on this important subject next October. The subject will be introduced by a brief survey of the position of colloidal physics and chemistry and discussion will then follow on the following sub-divisions emulsions and emulsification; physical properties of elastic cells; cataphoresis and electro-endosmose precipitation in disperse systems; gels and pyrosols non-aqueous systems. The exact date and place of meeting and further particulars will be announced later. In the meantime anyone desirous of using the opportunity of the discussion to bring forward experimental matter or theoretical considerations bearing on the above-mentioned branches of the subject is asked to communicate as soon as possible with the Secretary of the Joint Committee, Mr. F. S. Spiers, 10, Essex-street, London, W.C. 2.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

State of Trade.—Although it is now rather more than the calendar half-year the present is usually looked upon as the time for reviewing the six months' trade. In looking over that period one cannot fail to be struck by the tremendous amount of activity which has prevailed throughout the country. One or two industries have certainly not participated quite so much as the majority of others, but a good tone has been general over all and an excellent output has taken place. With so much business passing there have been many extensions to premises and much new machinery of the most up-to-date kind installed, with the natural result that all engineering works have experienced great activity. Their output has naturally been retarded by the great difficulty in securing a sufficiency of raw material, chiefly iron and steel. The producers of the latter have gone through a terribly hard time in endeavouring to keep all their customers going along satisfactorily. The output has been large, but at no time anything like equal to the demand, and many a time it has only been limited by the amount of raw material which they could secure. The question of supplies has been a very serious one during the past half-year, and it cannot be said that the future holds out hopes of being much better. During the period under review prices have ruled at an unheard of figure, and as yet they do not show much, if any, sign of weakening. Buyers have an idea that the top has been reached, and that the present level cannot be maintained much longer, and are, in consequence, holding out of the market at present with all except the most urgent business. One notable feature in the work of the period is that despite the large output only a very small proportion of it has gone abroad, the home trade having consumed nearly all of it. Our export trade in steel and iron has been but a shade of what it was in pre-war days, and although some most tempting inquiries have come along from foreign buyers all of these had to be turned aside owing to the needs of the home consumers. When work is resumed after the holidays in the Glasgow area next week, there are any amount of orders to commence with, and some works have as much booked as to carry them on nearly up to Christmas.

Scotch Steel Trade.—There has been practically nothing doing in the Scotch steel trade during the past week on account of the holidays which are still on. Repairs are being carried out on an extensive scale, and all is being got in readiness for restarting on Monday next. Order books are full, and much activity is expected to prevail during the next few months. All the regular customers are forward for supplies against contracts, but new business is rather quiet. Black steel sheets are a very bright spot at the present time, and the work on hand amounts to a very large tonnage. Prices continue very firm all round.

Malleable Iron Trade.—The holiday respite was welcomed in the malleable iron trade of the West of Scotland after the very busy period of the past few months. The pressure for deliveries was at times very heavy, and similar conditions are anticipated when business is resumed next week, as bookings are large. Inquiries over the week have been satisfactory, and prices remain strong.

Scotch Pig-Iron Trade.—When general business is resumed next week a big rush of orders is expected in the Scotch pig-iron trade, but producers have provided against this, and little disappointment is anticipated as stocks have been accumulating in a small way. The necessary preparations have been taken to ensure a little better delivery, but unless raw material continues to come in in large quantities, conditions will not show a very great improvement. The scarcity of all grades of iron during recent months has been the source of much annoyance to consumers, and it is hoped that the worst stage of that state has been passed by. Prices all round are very firm.

Steel Nails.—Intimation has been made by the local nail makers that they now intend to quote "fixed prices," thus abolishing the "subject to advance" clause which has been in use for some time back. That clause has been far from satisfactory to buyers, and its disappearance will give much satisfaction all round in future. Very brisk conditions have ruled throughout the trade recently, and order-books are still well filled up.

BRITISH INTERNATIONAL MOTOR-BOAT TROPHY.—The international motor-boat race for the above trophy has been fixed to take place on August 10, 11, and 12, in Osborne Bay, and the eliminating trials, to decide which boats shall represent this country, are to be held on July 28 over the same course. Two entirely new boats are being built for this race by Messrs. S. E. Saunders, Limited, in their yard, East Cowes, and as they were responsible for the construction of Maple Leaf IV, the last winner and present holder of the trophy the following brief details may be of interest:—(1) Sunbeam-engined racer (Sir E. Mackay Edgar, Bart.) Length, 39 ft.; four Sunbeam engines; two propeller shafts; each engine giving 450 h.p. (2) Rolls-Royce-engined racer: Length, 39 ft.; two Rolls-Royce engines, each engine giving 550 h.p.; two propeller shafts. Both boats will compete in the eliminating trials on the 28th inst. The three boats which will represent America in the international race, have already arrived safely and are, in fact, housed at Saunders' yard at East Cowes. There is every prospect of this year's race proving even faster and more exciting than was the case on the last occasion, when Maple Leaf IV broke all records by attaining the speed of nearly 50 knots.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Market.—The most interesting development since last week was the instruction issued to-day by the local representative of the Coal Controller that exporters must increase their shipments to the coaling stations and to Italy, and it was stated the full quota had not been supplied to the destinations indicated, while to other destinations shipments had exceeded the allocations. In these circumstances it transpired that to-day the authorities declined to release coal for France, while it was further stated that exports to Portugal would be suspended for a month. Collieries yesterday were supplied with permits to cover them till August 28—a period of five weeks instead of the usual four weeks. It was understood that this course was adopted in order to provide for the intervention of the August holidays, which will necessarily result in a further diminution of output. Taking the market generally there has been no marked change, and exporters find the utmost difficulty in arranging any new business.

Welsh Colliery Deal.—Another important colliery deal was reported last evening, when it was officially announced that the two well-known Welsh coal magnates—Mr. D. R. Llewellyn and Mr. H. Seymour Berry—had concluded negotiations for the acquisition of the whole of the mineral rights underlying the Abercpergwm estate in the Glyn Neath and Dulais Valleys, in the western portion of the Welsh coalfield, over 4,000 acres in extent, and including the collieries of the Abercpergwm Company, Limited. The upper measures are steam coal and the lower measures anthracite. It is intended in due course to utilise the present modern power station at Abercpergwm for the electrification of the whole of the undertaking. It is estimated that the unworked quantity of coal in the area now acquired to be about 1,200,000,000 tons, and it contains about a tenth of the unworked coal of the whole Welsh coalfield.

BRITISH ENGINEERING STANDARDS ASSOCIATION.—The British Engineering Standards Association held its second annual meeting on Thursday, the 15th inst., at the Institution of Civil Engineers, when the chairman Sir Archibald Denny, Bart., presented the report and dwelt with especial emphasis on the need for further financial support. Like last year, the chairman was able to chronicle further progress both at home and abroad. The Association is rendering an indispensable service to British trade at home in co-ordinating standards promoting efficiency and eliminating waste, and is also doing much to push British trade abroad. It is, therefore, regrettable that even after twenty years of useful work the engineering industry of the country is only now slowly putting the Association in a position adequately to cope with the increasing demands made upon its organization. There are some 300 committees, counting over 1,400 members, who, the chairman pointed out, give their time and experience often at great personal expense and inconvenience to this great national work and the country as a whole, as well as its industry, owe a deep debt of gratitude to these gentlemen for their service, and also to the engineering firms who allow their engineers, managers and others to take part in the work. The national importance of the Association in the development of trade both at home and abroad, is, however, being more and more appreciated, and the increased demands being made on it by the industry augurs well for its future. Since the last annual meeting, 27 British standard specifications had been issued and some 70 are under revision, the most important of which dealing with steel sections for general building construction, including shipbuilding, has just been completed. The Association is drafting British standard specifications for various chemical products, copper alloys, materials and constructional strength of chemical fire extinguishers, steel-wire ropes, steel bridge construction, and milling cutters and reamers. Some 45 British standard specifications for electrical apparatus are also in course of preparation. The work of standardizing details in the construction of ships and their machinery is also making good progress; the panels which meet on the Clyde have done a large amount of preliminary work and their proposals now only await discussion and final agreement with similar panels on the North-East coast for them to be available publicly. The Marine Engineering Committee, in which the Board of Trade, the Classification Societies and the superintending engineers are taking an active part, is also making rapid progress. The question of the standardization of tail shafts is approaching completion. That an organization such as this could close the financial year with a deficit of £1,100 is a matter which no doubt will be dealt with by the industry at once and generously, and it is to be hoped that the appeal now being made to those firms who have not so far subscribed at all, and also to those who are already subscribers, will at once be responded to, especially as their annual contributions can be treated as a trade expense. We understand, in fact, that some encouragement has already been received to the effect that the comparatively low figure of 15,000*l.* to 20,000*l.* required during the coming year will be forthcoming, since a number of leading firms, who are perhaps more closely in touch with the actual work carried out by the Association, have increased their support by, in many cases, doubling their subscriptions. It is interesting to see that the engineering public is making increased use of the British standard specifications, for the chairman stated that 31,000 of the specifications had been sold almost all in this country against about 3,000 in pre-war years.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The Cleveland pig-iron trade shows little change of moment, but it is gratifying to learn that furnaces which had dropped on to the make of inferior iron are returning to the production of foundry quality of which there is quite a famine. Home demand for Cleveland foundry pig is far more than can be coped with, there being pressure for supply for use in the Midlands and South Wales, as well as in districts usually served by Cleveland, and producers are rigidly adhering to their decision not to sell for abroad so long as home requirements absorb output. Forge iron is comparatively plentiful. For home consumption No. 1 Cleveland pig is 230*s.*, and No. 3, as well as the inferior qualities, is 217*s.* 6*d.*

Hematite Iron.—Scarcity of hematite is very pronounced. Hardly any is purchasable for shipment abroad, and most makers are disinclined to discuss home business, having sold as heavily as they care to commit themselves. A small sale to a neutral destination, however, is reported at 300*s.* To home customers No. 1 hematite is put at 262*s.* 6*d.*, and mixed Nos. at 260*s.*

Foreign Ore.—Inactivity still characterises foreign ore. Sellers are more in evidence than they have been, and some are keen to do business after the long period of idleness. The position is easing, and no doubt concessions would be made to secure contracts, but consumers continue to hold aloof. They are well placed having fairly good stocks, and substantial quantities coming forward, so that they can afford to wait in the hope and belief that market movement will continue in their favour. Quotations are based nominally on 49*s.* for rubio of 50 per cent. quality, on the 17*s.* parity freight Bilbao-Middlesbrough. That is quite a seller's quotation, and as the best offer for steamers from Bilbao is now 21*s.* 6*d.*, the c.i.f. Tees value of best rubio cannot be put above 53*s.* 6*d.*

Coke.—Coke keeps steady and firm. Foreign transactions are difficult to put through, but the home market is rather active. Medium blast furnace coke is 32*s.* 9*d.* at the ovens; and quality low in phosphorus is 65*s.* 3*d.* at the ovens.

Manufactured Iron and Steel.—Little new is ascertainable concerning the various branches of the finished iron and steel industries. Manufacturers are full of work, and are running, as fully as circumstances permit, on execution of existing contracts. Competition of America and of Belgium is increasing, and new business is not easily put through, but values are well upheld. Principal market quotations stand:—Common iron bars, 30*l.*; marked bars, 32*l.*; iron angles, 30*l.* 15*s.*; steel ship, bridge, and tank plates, 23*l.* 10*s.*; boiler plates, 30*l.*; steel angles, 23*l.*; steel joists, 23*l.*; soft steel billets, 25*l.* 10*s.*; hard steel billets, 26*l.* 10*s.*; heavy steel rails, 23*l.*; fish plates, 28*l.*; black sheets, 44*l.* 10*s.*; and corrugated galvanized sheets, 56*l.*

TRADE WITH SWEDEN.—Mr. H. Kershaw, whose appointment as Commercial Secretary to H.M. Legation at Stockholm was announced in May, has now left the Department of Overseas Trade to take up his post in Sweden.

THE EDGAR ALLEN NEWS.—The issue of No. 7 for July of this journal contains a series of interesting articles on the heat treatment of steel, on steel testing, the wear of rails, &c. A novel feature which is started in this issue, consists of a dictionary of steel and engineering technical terms.

THE MISCELLANEOUS TRADES OF SHEFFIELD.—A recent pamphlet issued by the City of Sheffield Development Department, Town Hall, Sheffield, gives illustrated information on Sheffield trades, type-casting, glass and lens making, &c., in which the city has acquired a reputation equal to that which surrounds Sheffield steel and Sheffield steel articles.

PERSONAL.—Engineering appointments:—Mr. E. Rawson, B.Sc.Eng. (Lond.), A.M.I.Mech.E., head of the engineering department at the Municipal College, Portsmouth, has been appointed to the post of principal of the West Bromwich Municipal Technical Institute.—Lieut.-Colonel G. P. Mills, D.S.O., M.I.M.E., M.I.A.E., has been appointed chief engineer to the Aster Engineering Company (1913), Limited.

WORKS ORGANIZATION.—In order to obtain some insight into the working and construction of their various manufactures, the head office staff of Messrs. G. Kent, Limited (London), visited Luton on July 17 last, technical details being explained to them by experts in the different departments. They were also shown the latest improvements in machinery and equipment recently installed. Such visits as these should prove of great educational value to all concerned.

BRITISH INDUSTRIES FAIRS.—The President of the Board of Trade has appointed a committee under the chairmanship of Sir Frank Warner, K.B.E., to consider the best policy to be adopted in future as regards British Industries Fairs, particularly in respect of the centres at which they should be held, the trades which should be included, and the classes of exhibitors who should be allowed to participate. Mr. A. G. Chuter, M.B.E., of the Department of Overseas Trade, has been appointed secretary to the committee.

AEROPLANE ENGINES AT THE INTERNATIONAL AERO EXHIBITION, OLYMPIA.

(*For Description, see Page* 106.)

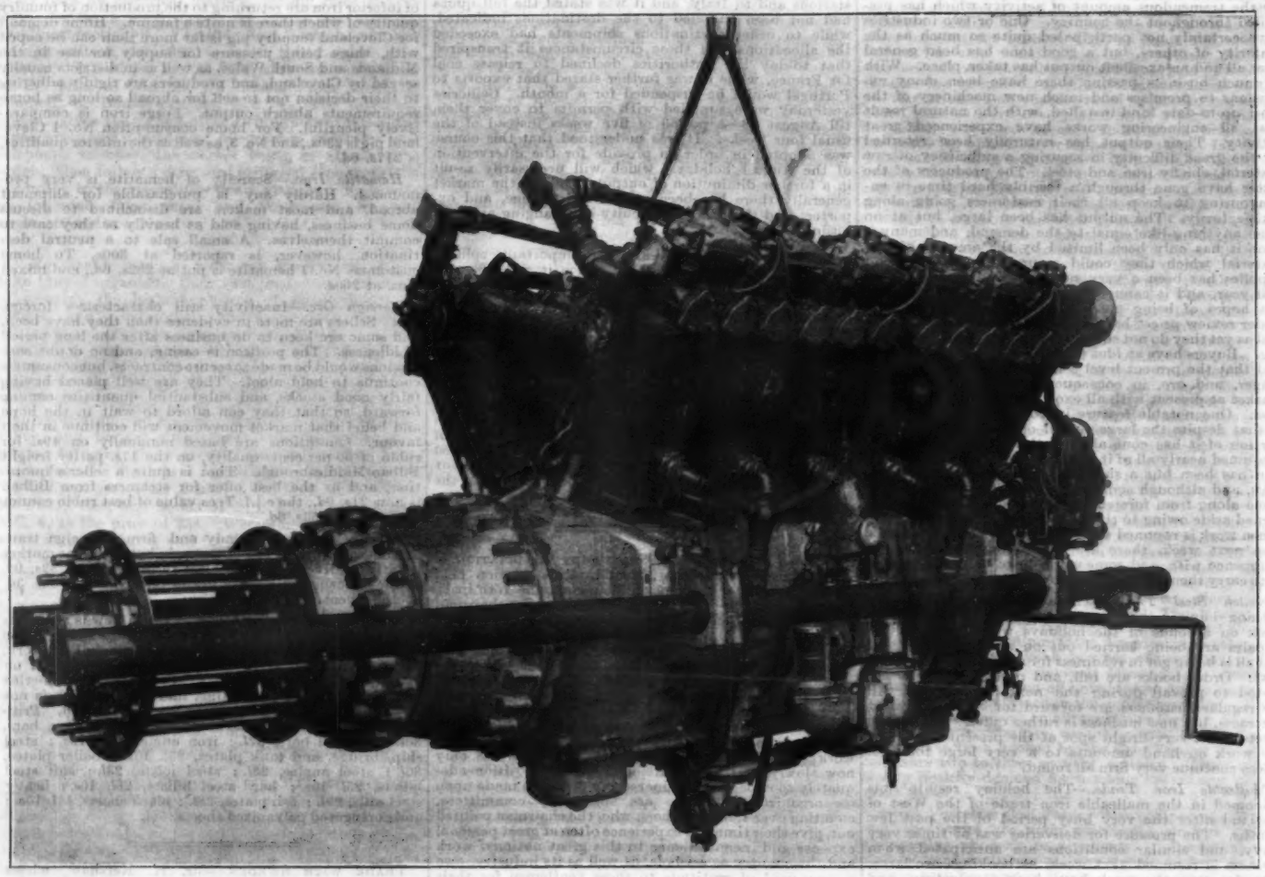


FIG. 22. 600-H.P. 12-CYLINDER "CONDOR" ENGINE; MESSRS. ROLLS-ROYCE, LIMITED, ENGINEERS, DERBY.

CALCUTTA WATER SUPPLY.—The Calcutta journal, *Statesman*, for June 8, says that Mr. St. George Moore, M.Inst.C.E., who was engaged to advise the Corporation of Calcutta regarding the improvement of the water supply of that city, has submitted his report. In this, he expresses the opinion that the water supply in question is in a serious position and calls for drastic remedies with all possible speed. The complaint is general, particularly in the southern area of the city, that the present supply is inadequate. The scheme which he has put forward, and of which particulars are given in the journal, aims at providing Calcutta and its suburbs with, roughly, 100,000,000 gallons per day; a continuous supply distributed by independent mains to well-defined zones. On the population of 1941, as he has worked it out, this would insure in that year a supply of 80 gallons per head per day within the city boundaries.

TRADE WITH SIAM.—In his report on the commercial situation in Siam at the close of 1919, Mr. J. Crosby, H.M. Acting Consul-General in Bangkok, states that importations in iron, steel and machinery from the United Kingdom ceased entirely during the war. America, as long as she remained neutral, thereupon became the chief source of supply, providing in particular steel plates and sections. As regards machinery, the chief importations from America have been four drag-line excavators and two suction dredges for the Royal Irrigation Department. From the time that America began to participate in the war, however, imports of iron, steel and machinery from that quarter all but ceased. After the termination of hostilities in November, 1918, practically no business was done, in the vain expectation that prices would drop. At about the end of June, 1919, orders began to be placed again through sheer necessity. None of these have yet had time to come forward; it is probable that the bulk of them have gone to the United Kingdom. There is every prospect that, provided labour troubles do not stand in the way, the United Kingdom will recover and even improve her old position in this market. But it is most desirable that home manufacturers should be able to quote firm prices for forward contracts for reasonably prompt acceptance, and that they should adhere to terms of reasonably quick delivery.

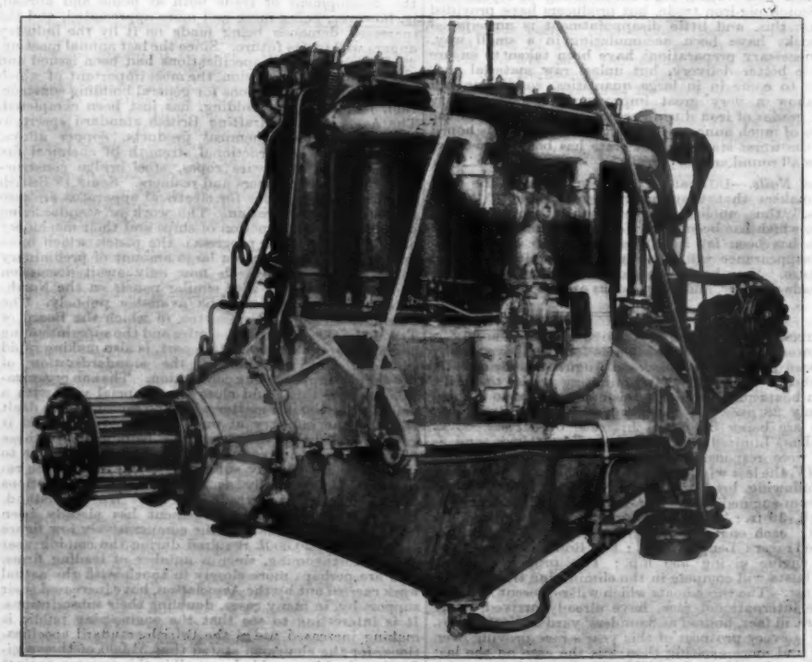


FIG. 23. 100-H.P. 6-CYLINDER "HAWK" ENGINE; MESSRS. ROLLS-ROYCE, LTD., ENGINEERS, DERBY.

1,250-B.H.P. UNIFLOW STEAM ENGINE.

CONSTRUCTED BY MESSRS ROBEY AND CO., LIMITED, ENGINEERS, LINCOLN.

(*For Description, see Page* 104.)

Fig. 30.

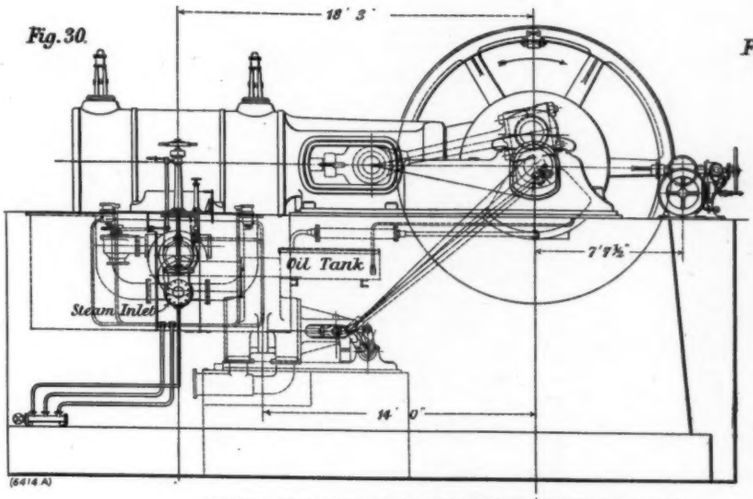


Fig. 31.

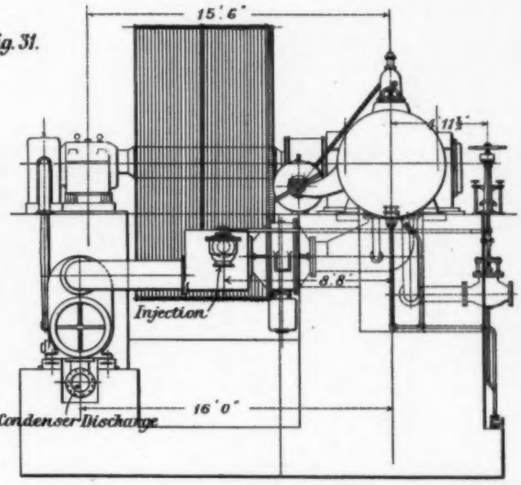
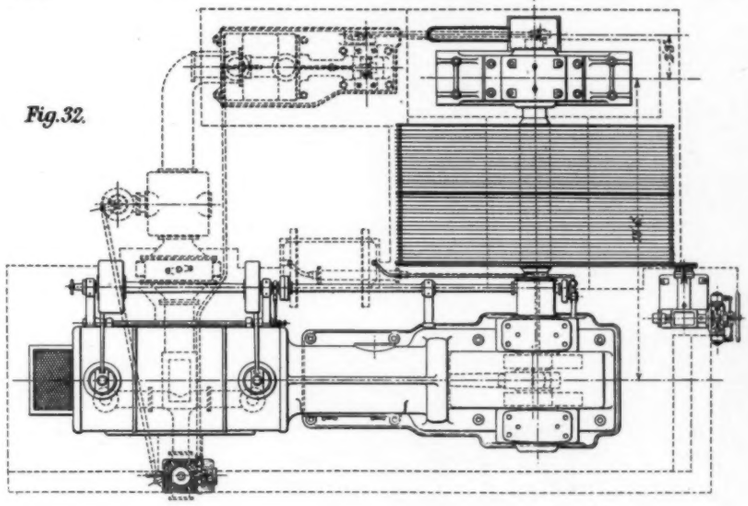


Fig. 32.



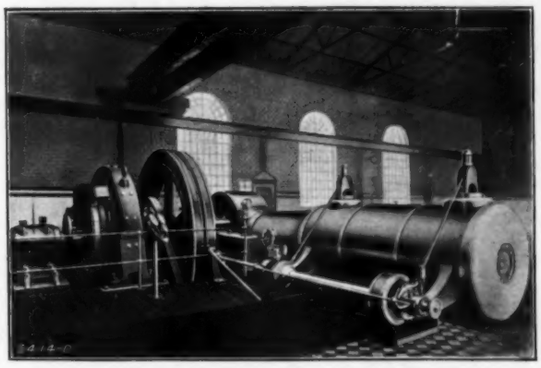


FIG. 33.

Fig. 34.

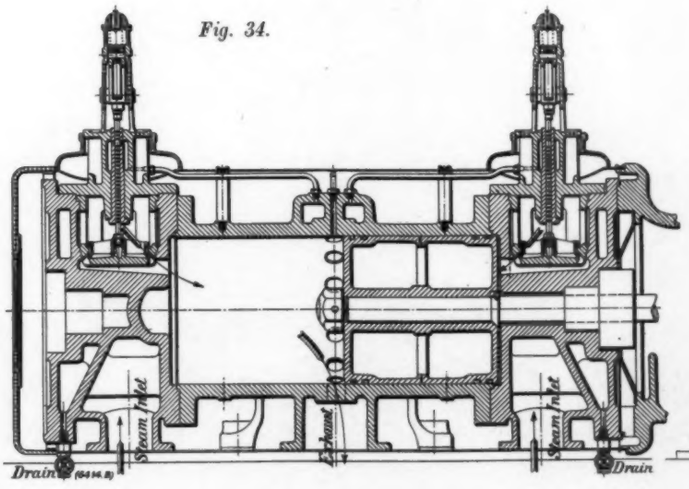
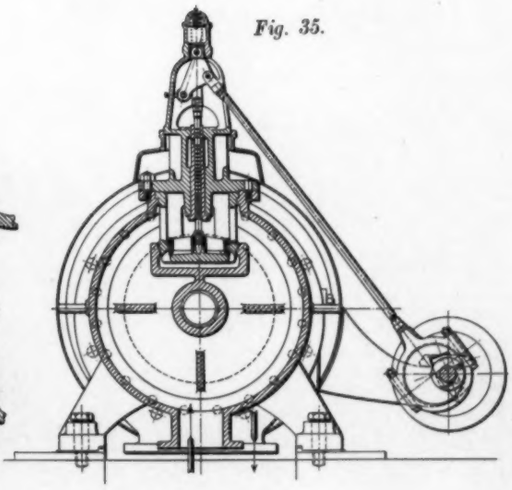


Fig. 35.



(*To face page* 118.)

450 H.P. AEROPLANE ENGINE; AERO INTERNATIONAL EXHIBITION.

CONSTRUCTED BY MESSRS. D. NAPIER AND SON, LIMITED, ENGINEERS, LONDON

(*For Description, see Page* 106.)

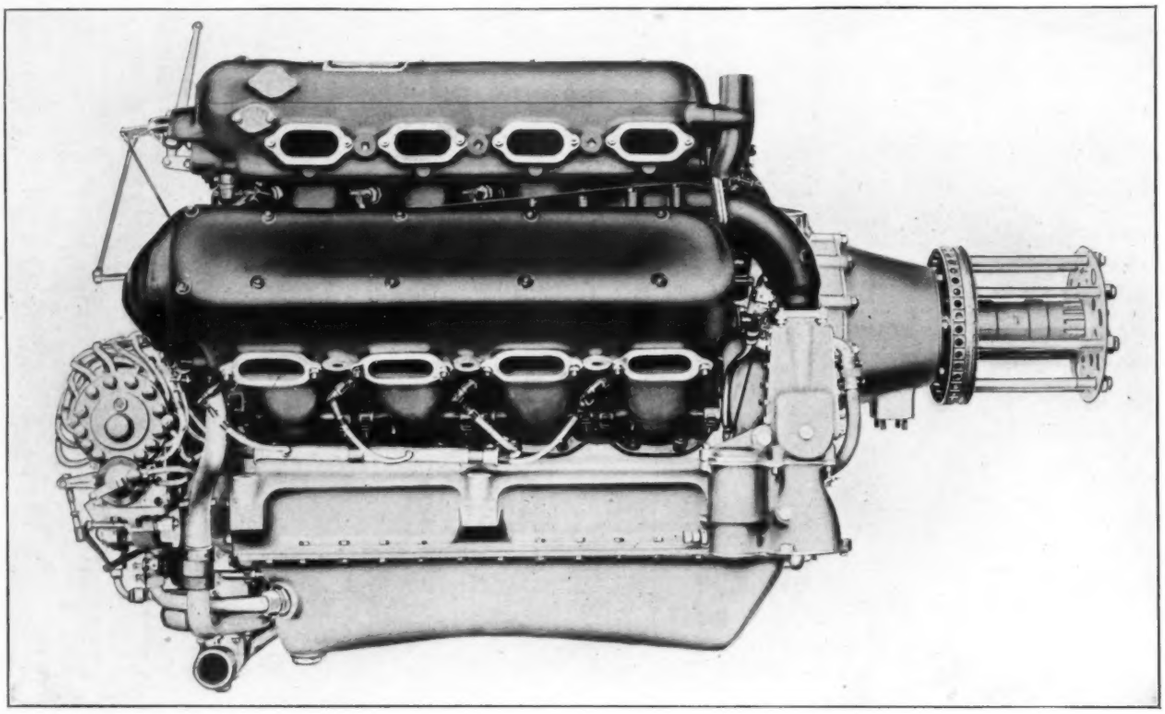


FIG. 13.

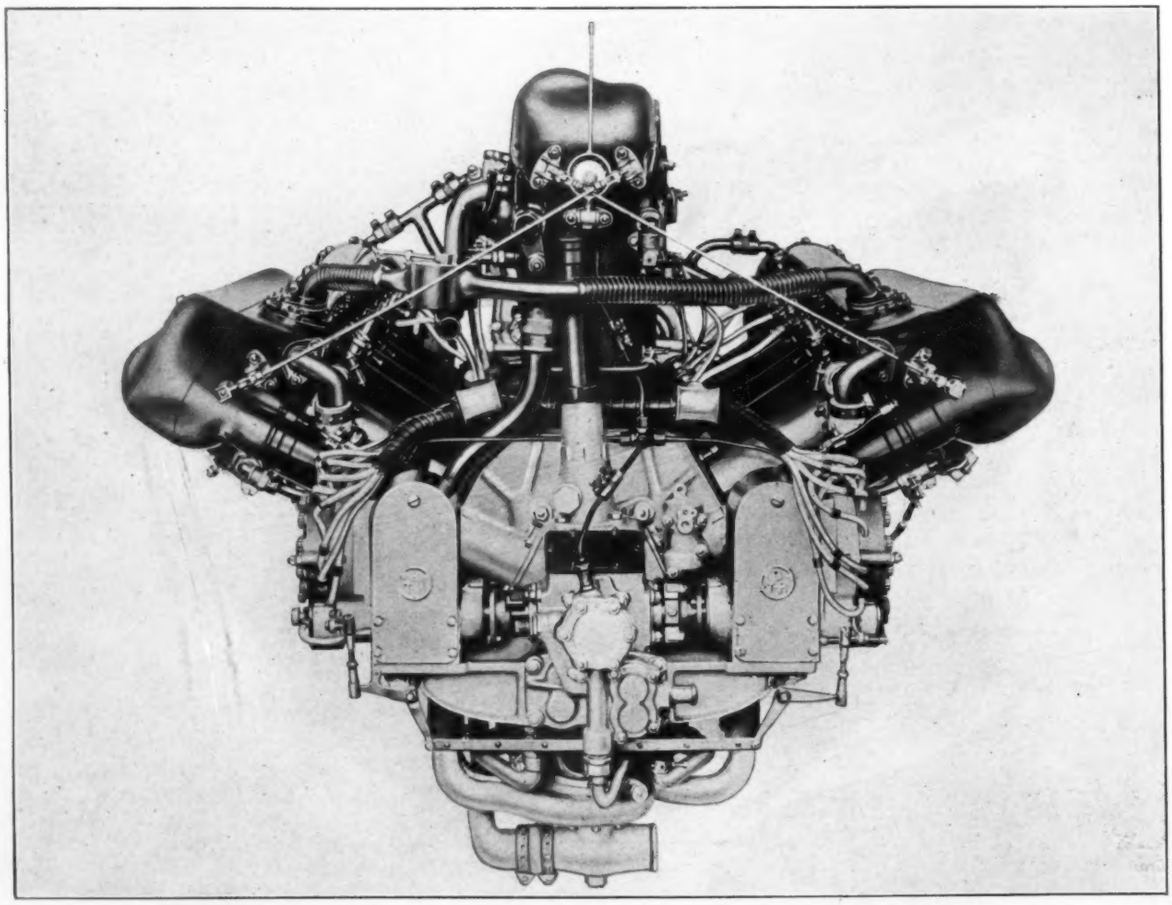


FIG. 14.

450-H.P. AEROPLANE ENGINE; AERO INTERNATIONAL EXHIBITION.

CONSTRUCTED BY MESSRS. D. NAPIER AND SON, LIMITED, ENGINEERS, LONDON.

(*For Description, see Page* 106.)

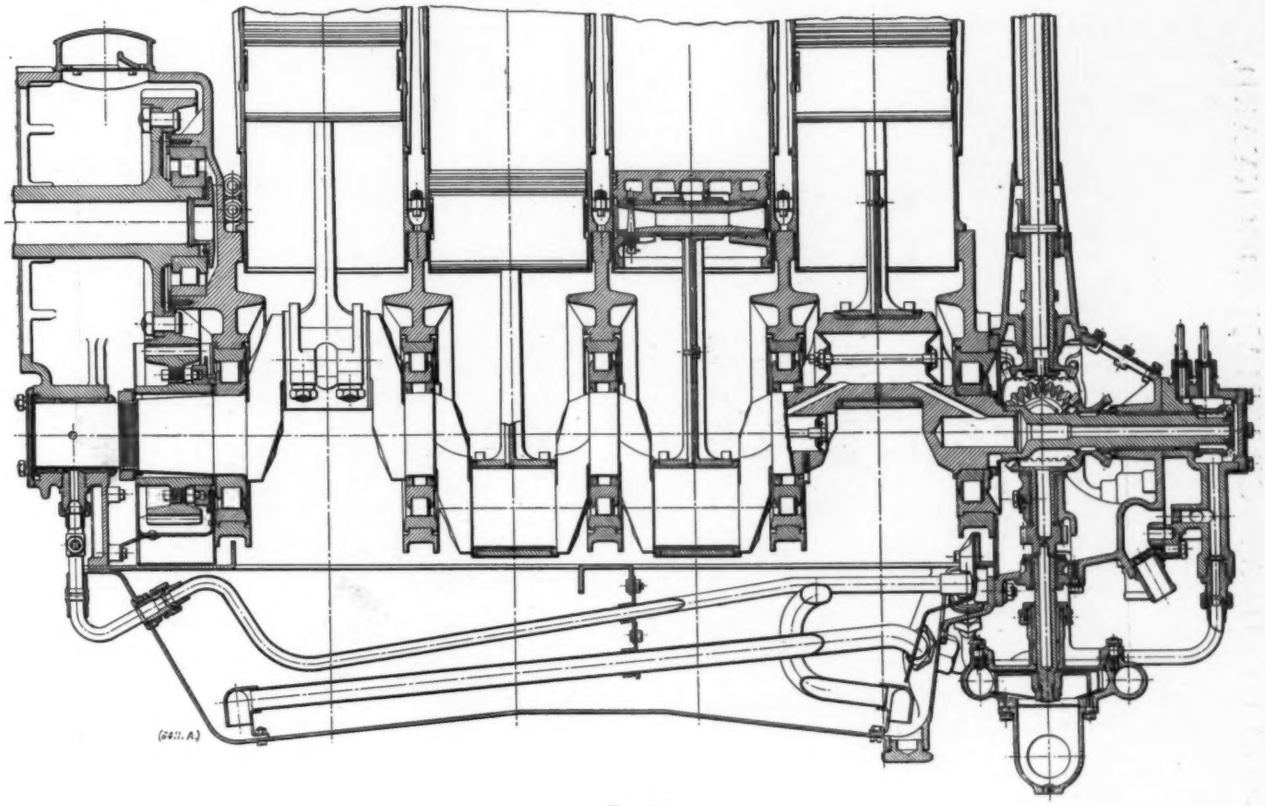


FIG. 15.

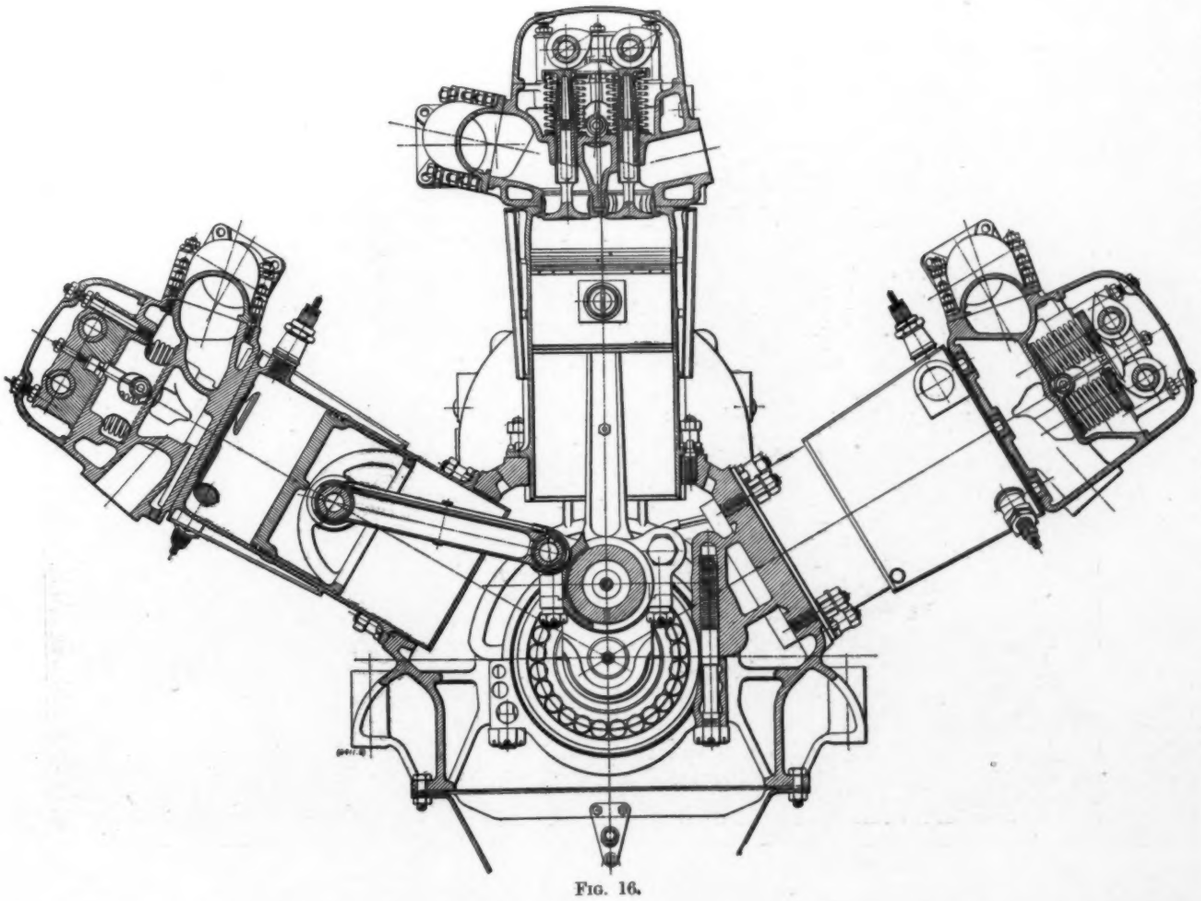


FIG. 16.

EXPERIMENTAL DIESEL ENGINE CONSTRUCTED AT CHATHAM DOCKYARD.

(*For Description see Page* 127.)

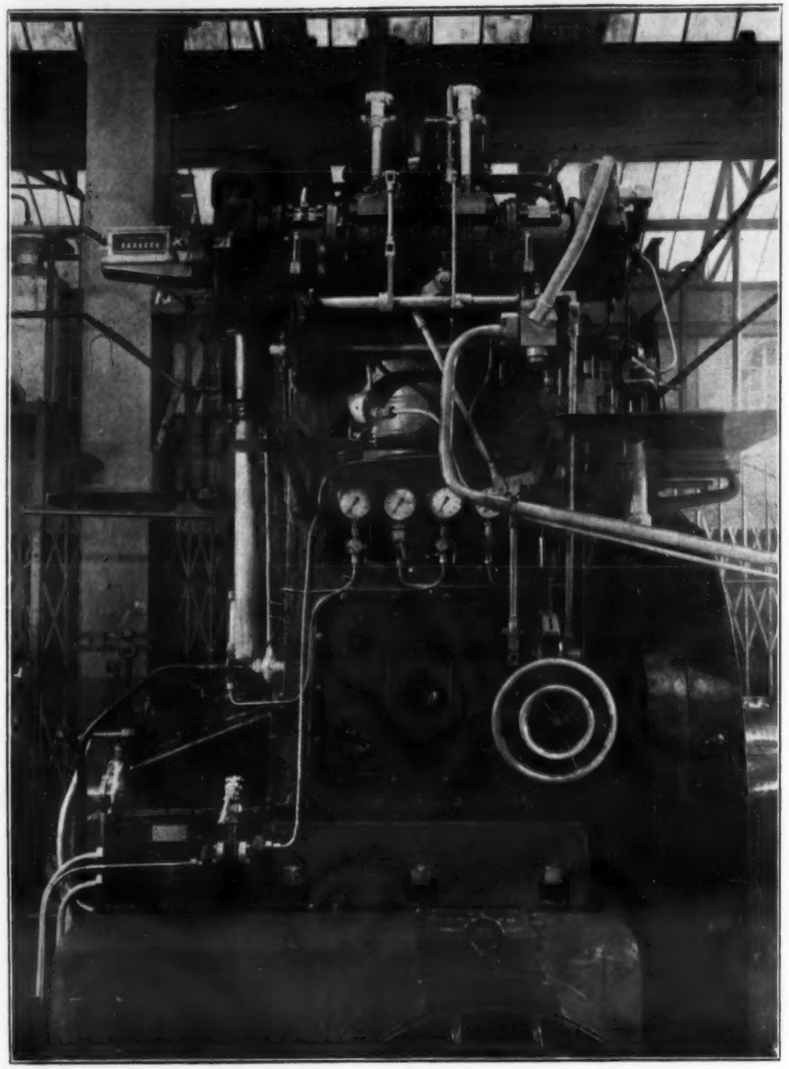


FIG. 5.

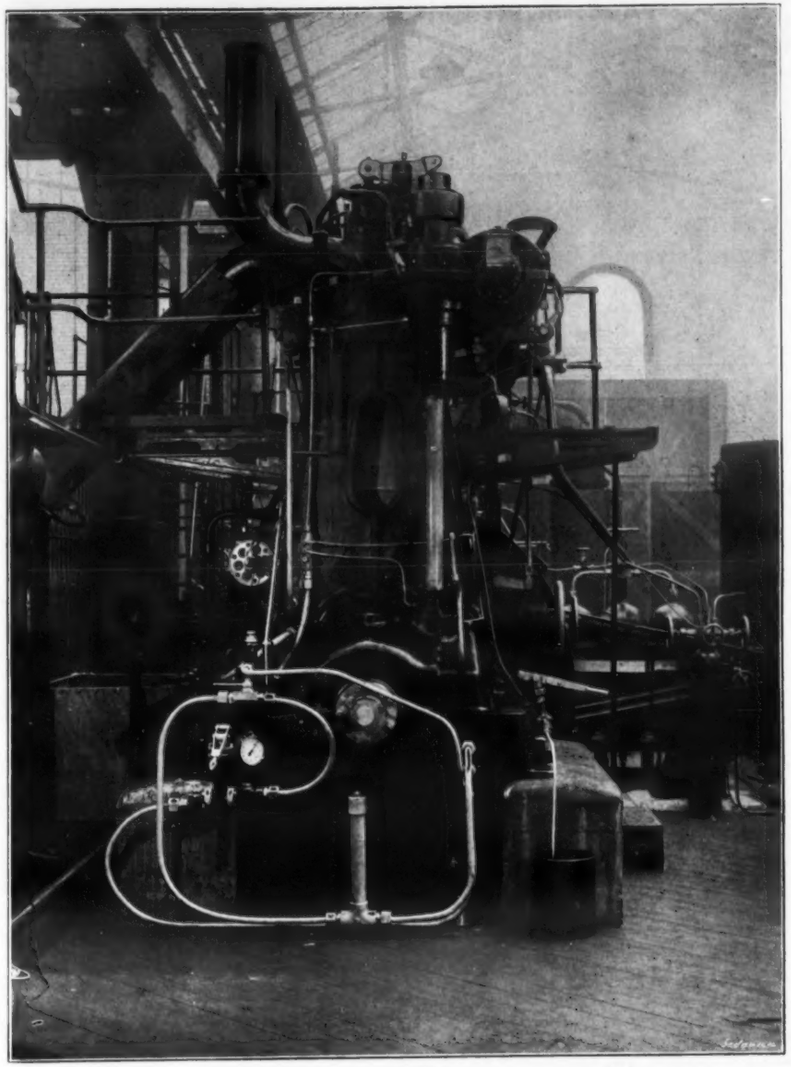


FIG. 6.

(*To face page* 119.)

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS: "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3643 and 8598 GERRARD.

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With One One-Page Plate of the 1250-B.H.P. *UNIFLOW STEAM ENGINE; Two One-Page Plates of the* 450-H.P. *AEROPLANE ENGINE AT THE INTERNATIONAL AERO EXHIBITION; and One One-Page Plate of the EXPERIMENTAL DIESEL ENGINE CONSTRUCTED AT CHATHAM DOCKYARD.*

NOTICE.

A few months ago the Proprietors of "ENGINEERING" were compelled to advance the price of this Journal to 1s. per copy, owing to the enormous increases in the cost of paper, engravings and printing, &c. Now higher transport and delivery charges involve a further increase to 1s. 2d. per copy, and this price dated from and included the issue of Friday, April 2, 1920. So long as postal rates remain as at present there will be no increase in the price of copies sent by inland post, which will continue at 1s. 2d. post free.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents will not have copies for chance customers; therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

ENGINEERING.

FRIDAY, JULY 23, 1920.

SHIPS' BULKHEADS AND SAFETY.

ARE we to have another controversy on the subject of ships' bulkheads and safety? Most naval architects thought the agreement reached at the International Conference immediately before the war gave reasonable prospect of universal action. This, however, has not so far been the result. And now there is a tendency to inquire whether the war experience with merchant ships, which were torpedoed or mined, does not call for some reconsideration of the whole or part of the problem. It was this state of uncertainty which invested with importance the discussion on the papers read before the Institution of Naval Architects at their summer meeting at Liverpool, by Sir Westcott Abell, K.B.E., of Lloyd's, on "Safety of Life at Sea," and by Mr. George Webster, M.Sc., on "Subdivision of Passenger Ships," which opened the question of the best position of bulkheads in ships for safety. Both papers were reproduced in last week's issue, along with a full report of the discussion, which revealed clearly defined cleavage in opinion. To a correct understanding of the controversy it is necessary briefly to review the history of the subject. It was in 1891 that the spacing of bulkheads was first systematically dealt with by the Board of Trade. Vessels had been built previous to this date with very minute subdivision, notably the National liner America, and the Inman Line steamers City of New York and City of Paris. These were, for their time, highly developed passenger vessels, and the safety of the passengers was the prime consideration. A committee was appointed by the President of the Board of Trade to deal with all classes of ships, and the results of the work of this committee were published in 1891. Methods were given whereby the total length which may be flooded in any part of the vessel's length could be determined, so as to make her capable of remaining afloat with one or two compartments flooded, according to the grade to which she belonged, but this system was not universally considered as based on sound principle.

In 1913–14 the International Conference on "Safety of Life at Sea" reviewed the whole question of subdivision of ships. A committee of the Board of Trade, presided over by Sir Archibald Denny, Bart., LL.D., had been sitting for some time on this question when the International Conference was formed, and some of its members took part in this Conference. The work of the committee was completed after the Conference and, subsequently, the Board of Trade regulations were issued, which gave effect to this committee's report, as well as to that of the International Conference. These regulations make it compulsory to have a definite amount of subdivision. The only compulsory part of the 1891 Committee's work related to the amount of subdivision that was necessary in a ship in order that the amount of life-saving appliances could be reduced by one-half. It was the accident to the Titanic, which startlingly called attention to the question of subdivision and of life-saving appliances, and led to the International Conference referred to; but the general opinion entertained was that the great loss of life was due to the insufficiency of life boat accommodation carried and to the fact that it was inadequately utilised. The Titanic was a very well subdivided vessel.

Between 1891 and 1913–14 the standard of safety which was aimed at by subdivision was that a ship should remain afloat with one compartment flooded, and further that as a greater degree of safety in some cases she should be capable of remaining afloat with two compartments flooded, so as to provide for the contingency of a blow being struck rending the shell as well as a bulkhead dividing two compartments, and making both open to the sea. These two conditions really resolve themselves into one problem, namely, that of finding what length of a ship could be flooded without passing the margin of safety. In the first case the question would be what length would be flooded when a bulkhead was not struck, and in the second case when it was struck. In the first instance it would be the length of one compartment, in the second it would be the length of two adjoining compartments. It is evident that for ships of definite proportions this length of one or alternatively two compartments would be a definite percentage of the length of the ship, whatever the absolute length might be. The percentage of length which gives the same measure of safety varies with the position of the compartment between bow and stern; it also varies with the ratio of freeboard to draught. This length of compartment, which is usually called the "floodable length" is at a minimum at 20 per cent. of the length from each end of the ship. The length of the compartment is about 15 per cent. of the length of the ship when the freeboard is 20 per cent. of the draught, increasing to 25 per cent. or even 30 per cent. of the length of the ship when the freeboard is 60 per cent. of the draught. The floodable length also varies with the form of the ship and with sheer, but these causes of variation do not come into the question as dealt with by Sir Westcott Abell. These percentages of length of ship which can be flooded without passing the margin of safety give the spacings of bulkheads for what is called the one or two-compartment ship, and they are practically constant percentages, regardless of absolute dimensions. A constant percentage gives a shorter hold in a short ship than in a long one. Convenience of shipping and stowing cargo depends on the lengths of hold. The length of a compartment has, therefore, to be considered from the point of view of convenience of cargo carrying as well as from that of safety of the ship. While 15 per cent. of a 600-ft. ship will give a compartment 90 ft. in length, which is ample for cargo considerations, it only gives 45 ft. of length in a 300-ft. ship which for some cargo purposes is not sufficient. It will thus be seen that it is easier to get good subdivision, or safety consistently with efficient cargo carrying in a long ship, than in a short one.

The International Conference introduced a new method of viewing this question, and instead of talking about a one, two or three-compartment ship they introduced a "factorial" system by which a permissible length of compartment is obtained by multiplying the floodable length by a factor, this factor being 1.0 for the shortest one-compartment ship, 0.5 for the shortest two-compartment ship, and 0.33 for the shortest three-compartment ship. For any lengths within those named a factor intermediate to those named had to be chosen, so that in effect between the lengths of 295 ft. and 571 ft. subdivision was such that it might be called something between a one and a two-compartment ship. The effect of this was to give a greater degree of safety as the length increased, expressed in the form of the vessel having a greater margin of safety, or that she would not be sunk so deeply in the water when a compartment was flooded as the length increased. The one, two and three-compartment ships were reckoned respectively as 295 ft., 571 ft., and 900 ft. long. It is evident that for a length a little less than 571 ft. the ship was not a two-compartment ship, and for a little more than 571 ft. she was a two-compartment ship. For a length of a little less than 571 ft. if struck on a bulkhead she would sink; for a little more than 571 ft. she would not sink. This change was made to avoid such a misunder-

standing by the public as is instanced. A two-compartment ship, if a little less than 571 ft., with the same proportionate subdivision, would be a one-compartment ship, and for a little more than 571 ft. could be called a two-compartment ship. It was a matter of policy adopted to avoid misleading the public. It was considered that safety is conditional. It depends on the permeability of the cargo and this is a very variable quantity. No action that could be taken by the legislature could ensure a constant permeability or buoyancy in the cargo, and consequently the assumed conditions of flotation in a damaged condition could not be ensured; the safety could only be conditional upon the amount and quality of the cargo carried.

It is only since the armistice that the work of design of merchant ships to fulfil the Board of Trade conditions as to subdivision has been seriously undertaken, and in consequence it is only recently that the difficulties of carrying out these regulations have been realised. It is alleged that with the "mixed type" of ship the subdivision necessary to fulfil these requirements is too great for commercial purposes and Sir Westcott Abell in his paper proposes a modification of this subdivision. The damage caused to ships during the war by torpedoes and mines has led him to consider "The Odds on" for loss from damages for a much greater longitudinal extent than was considered by the International Conference. He calculates the chance of sinking by flooding compartments caused by damage extending for 10 per cent. of the length of the vessel, regardless of the length of the vessel. As an illustration he takes the case of a 400-ft. "standard" ship, one compartment of which has main holds 65 ft. in length, and has a damage 40 ft. in length. Such a vessel would remain afloat as long as the centre of the damage is more than 20 ft. from a bulkhead, so that with a compartment 65 ft. long there is a length of 25 ft. where damage 40 ft. in length can take place without causing the loss of the ship and the "odds on" for loss work out at 40 to 25 or 1·6 to 1·0. He also works out the "odds on" for lengths varying from 410 ft. to 700 ft., where in the case of the bulkhead spacing according to the Board of Trade Regulation "odds on" vary from 1·0 to 1·0 to 0·0 to 1·0—it is not clear how he arrives at their figures; he proposes a variation from the regulations which gives the "odds on" less in all cases below 570 ft. in length, but more in those above. The system which he proposes to adopt is one of dividing vessels into six grades ranging from those floating with any two adjoining compartments open to the sea to those with any one forward compartment open to the sea, thereby combining the one and two compartment standards in different ways, giving more protection to the forward end of the ship than to the after end, because it is more liable to be struck.

The introduction of the "chance" calculation opens up a wide subject for investigation. It was pointed out by Professor Welch that small variations in the length of damage considerably affected the "odds on"; it was urged by Sir John Biles that damage for a fixed proportion of length of the ship was not an ordinary kind of damage, and that the assumption of a fixed proportion was unfair to the longer ships, and that the amount of damage was much more likely to be of a constant absolute length than a constant percentage of the length. He also contended that, if chance was to be properly taken into account, chances other than those of length of damage must be taken into account. It was pointed out that the chance of watertight doors and sidelights being left open could not be ignored, and that the chances of what would happen under peace conditions generally were very different from those under war conditions.

While the general opinion expressed in the discussion seemed to be that the method of evaluating the safety of the ship proposed by Sir Westcott Abell was not complete or satisfactory, it was felt that the subject may be well worthy of further investigation, and it seems to us that the case of the "mixed type" of ship may well be re-considered by a properly constituted committee consisting of some of the members of the old Bulkhead Committee and the International Conference, and some of the shipowners representatives who are particularly interested in the mixed type of ship. We commend this matter to the serious attention of Board of Trade so that it may be determined whether the shipowners have a real case for relaxation of regulation or whether they are only trying to reduce the safety of the ships with a view to increasing their commercial efficiency. The convention called for an order of safety which in the mixed type of vessels is higher than existed in practice when the convention reported and must involve more bulkheads or more freeboard. It may well be that the shipowners are not prepared to give this higher order of safety and want to prevent the results of the International Convention from being given effect to. Such a committee as is suggested might very well determine whether it is possible to give effect to the views as to safety required by the commission and the views as to commercial efficiency required by the shipowners.

ARRESTING THE WAGES ADVANCE MOVEMENT.

THE award issued by the Industrial Court last week in the general wages' application of the Unions connected with the engineering and foundry trades is an important and significant document. The skilled trades claimed an advance of 6*d.* per hour for journeymen, and the General Workers' Union claimed an advance of 20*s.* per week for adults. Advances were claimed also for apprentices and youths. The application came before the Industrial Court under a standing agreement between the Unions and the Engineering and the National Employers' Federations, under which the Court were to consider what general alterations in wages, if any, might be warranted by the abnormal conditions existing and due to the war.

The previous award of March 10, 1920, was based on the brisk state of the engineering trades at the time, which the Court presumably expected to continue and which they considered should be taken into account as being among the abnormal conditions due to the war. The Court, indicated, however, that an alteration in the cost of living does not in itself necessarily warrant any corresponding alteration in wages now that the markets are again open, but that the remuneration of the workers should in ordinary circumstances depend on the value of the work done, which in its turn should depend on the state of the market and the demand for the products of the workshop. The Court has adhered to those views in the present award, and, notwithstanding a rise in the cost of living since the date of the last award, has refused to grant any general increase in wages. The employers, who had obtained information as to the state of the industry all over the United Kingdom, were able to satisfy the Court that there were indications in some branches of the industry of a falling-off in demand, and the Court came to the conclusion that there was not such an improvement in the state of trade or such an alteration of general conditions as would warrant a further general increase.

Although the workers will no doubt be disappointed with the failure of their application—and there are already indications of that—it can hardly be questioned that it is in the interests of the industry in general that wages should not be further increased at present. The repeated alterations in the rates of wages have made it almost impossible for manufacturers to quote fixed prices, and this has operated seriously against their chances of obtaining orders in foreign markets. Further, wages, and consequently, prices are already so high that the home manufacturers are finding it increasingly difficult to meet the competition of America, Germany, Switzerland, Japan and other countries in the foreign markets, and a further advance of wages at the present time would in all probability have been disastrous. The Unions will, no doubt, renew their claims at the first opportunity, but the award is evidence, for the time being, of the Court's appreciation of "the desirability"—to use its own words—"of securing and maintaining for a reasonable period a measure of stability in the engineering industry."

The futility of increasing wages in order to overtake the cost of living, which rises almost automatically with each increase, has been fully demonstrated, and the only remedy for the present state of affairs is for the nation's workers, of all classes and all grades, to do everything in their power to reduce the cost of living by increasing output.

FUEL FOR MOTOR TRANSPORT.

THE interim Memorandum on Fuel for Motor Transport presented to Parliament by the Fuel Research Board may somewhat disappoint those who had pinned their faith on power alcohol and who had looked forward to detailed definite proposals of a report rather than to general considerations and to the provisory "not yet" of an interim memorandum. Detailed reports will follow, Sir George Beilby said in explaining, together with Sir Frederick Nathan, the Memorandum to members of the Press last week. Meanwhile the Memorandum contains ample matter for serious consideration.

The chief sources of alcohol are starch and sugar; the chief accumulators of starch in this country are grain (barley), potatoes and mangolds. This year's petrol requirements of the United Kingdom are estimated by Sir Frederick Nathan at 250,000,000 gallons. For the production of as many gallons of 95 per cent. power alcohol we should want 4,170,000 tons of barley, 12,500,000 tons of potatoes, or 25,000,000 tons of mangolds, plants of which the country in 1919 only produced 1,200,000, 6,213,000 and 7,769,000 tons respectively. The arable soil of the country totals 21,000,000 acres; the gallons mentioned would claim nearly 9,000,000 acres, whilst only 1,870,000 (barley), 1,219,000 (potatoes), and 472,000 acres (mangolds), respectively, are actually under crop. The cultivation of these plants might officially be pushed, but we have seen something of the results of compulsory cultivation, and after all the gallon of alcohol from barley, potatoes and mangolds would cost 7*s.*, 8*s.* 6*d.*, 3*s.*, respectively, in raw materials, quite apart from the transport and the distribution of the alcohol. Outside the United Kingdom molasses are a raw material cheaply convertible into alcohol. Molasses are a by-product of sugar, but of refined sugar only, and hence the 2,500,000 tons of Indian sugar which is not refined do not count in this consideration. The Empire production of refined sugar of this season, estimated at just over one million tons, might yield 18,000,000 gallons of alcohol; the home distilleries are equipped for about 8,000,000 gallons, and the erection of additional distilleries would hardly be economical under present conditions; it would be better, probably, to make and to utilise molasses alcohol in the country of its growth. The sugar position is acute; before the war half the world's supply was Continental beet sugar. Though the output of cane sugar is being increased the additional power alcohol which may become available for export will not amount to much.

The cultivation of starch-giving plants is being pushed in the Dominions. But those products will be claimed as foodstuffs in the first instance, and their prices will rise in accordance. In the tropics other suitable raw materials, wasted so far, may be found. They are still being searched for, however, as well as new simple alcohol processes. In Canada wood cellulose is being studied in this connection. There are also mineral sources of alcohol upon which hopes have been built. The recovery of ethylene from coke-oven gas and coal gas and its conversion into alcohol is still in the experimental stage, but can hardly become important; it looks as if the same will have to be said about acetylene (from calcium carbide, &c.). Nothing has been heard of late about the acetylene-alcohol plants started in Germany and Switzerland; Sir Frederick Nathan did not refer to them in particular, merely remarking that calcium carbide is impossible without cheap power. Thus his able summary shows that the power-alcohol problem has not advancedmuch since the days of the pre-war conferences. But with the investigations proceeding, we need not take a pessimistic view, and the barrier to power-alcohol is not, or is no longer, the indifference and lethargy of the Government. The

Finance Bill now before Parliament provides for the use of power-methylated spirits. It enables the Board of Customs and Excise to make regulations as to the generation of power-alcohol and the composition and quantity of the denaturant; a cheap denaturant is shortly to be authorised, and the facilities for the importation and distribution of power-alcohol in bulk are to be extended.

Yet it is clear that in the United Kingdom alcohol from foodstuffs, home-grown or imported, cannot become the common motor spirit. Coal is, and is likely to remain, the world's principal source of fuel, as Sir George Beilby, the Director of Fuel Research, recently remarked in a discussion on the oil resources of the Empire. In this country, at any rate, coal is the natural source of heat and power, and we have to concentrate our energies on the adaptation of the products of coal to the purposes of transport by sea and land.

By processes of carbonisation and gasification, Sir George points out in the Memorandum, coal can be "sorted out" into gaseous, liquid and solid fuels, and the forms of fuel have to be adapted to every type of transport. Direct combustion will yield 30,000,000 British thermal units per ton of coal, 10 per cent. of which the best steam engine will place at our disposal in power; gas producers and gas engines will give us much higher percentages as power. The British gas undertakings at present obtain 6,000,000 B.T.U. per ton of coal in the form of town gas, 1,750,000 heat units in liquid products, and 17,000,000 units as coke. Recent improvements have raised the gas proportion to 9,000,000 B.T.U. and the liquid proportion to 3,500,000 units, leaving 15,000,000 units in the form of coke; the gas figure may be raised to 12,000,000 B.T.U. These, Sir George remarked, are actual figures realised. The million of British thermal units in gaseous form finds a ready market at 8*s.* or 9*s.*, as compared with 1*s.* 6*d.* for the raw coal or coke, which have about the same value. The fuel value of a pound of gas tar is 16,000 B.T.U.; by fractionation the liquids can further be sorted out into benzol, &c., fuel, oils and petrol, the most volatile products having the highest thermal value.

This important sorting out of "fuels" in its thermal and economic effects is especially being investigated at H.M. Fuel Research station of East Greenwich. The method of treatment has to be adapted to the type of coal. For there is no such thing as "average coal," Sir George emphasized, though company promoters often disregard that the process and plant must conform to the type of coal. The cost of 1,000,000 B.T.U. in the form of petrol, at 3*s.* per gallon, is about 21*s.*, or 2½ times that in gas, and 14 times that in coke. In the form of alcohol at 5*s.* per gallon, the 1,000,000 B.T.U. would cost 52*s.* From the thermodynamic point of view the thermal availability of the gas is at least as high as that of petrol; but when we have to carry fuel for long runs, petrol is obviously more convenient, since gas demands either very large or very heavy containers. Sir George Beilby summarised the position as follows: Means of sorting out the potential energy of coal into forms of different availability and commercial value are already in our hands. The use of the volatile products like benzol and light naphtha should be restricted to air transport and to swift road transport. Town gas and coke-oven gas might be extensively used in omnibus and passenger cars for quick traffic, if light and safe containers and replenishing stations could be provided. Low temperature carbonisation at 600 deg. C. would yield a town gas of twice the calorific power at present realised, so that the same containers would carry double the thermal units. Carbonisation at 600 deg. C. would give in its coke a tarless and smokeless fuel, easily lighted and kept alight, and admirably adapted for use in suction gas producers and engines, and the cost of the thermal units produced in this way would not exceed 3*s.* per million, or one-seventh of the cost of petrol units with petrol at 3*s.* per gallon.

Those suggestions are not mere possibilities. A great many types of coal have been investigated, and gas containers have been devised and examined. There is no trouble about the compression of the rich, low-temperature carbonisation gas. Alcohol does answer, and answers best, in fuel mixtures, and it has been found that heavy cars can be run on half-alcohol half-petrol mixtures, though not quite so efficiently as on petrol alone. Whether the gas companies will continue to strip the gas for benzol, or ought to be made to do so, is a question. Failing that source of benzol supply, the motor fuel position will certainly become serious. The United States produced last year 66 per cent. of the world's crude petroleum, but their own demands exceeded their production. They will be running more than 12,000,000 automobiles next year, and the United Kingdom will probably have 750,000. "Sorting-out" is imperative. The candle is a convenient and, in a measure, cheap source of light. But the illumination of a large hall by candles would be indefensible waste, and so is the propulsion of heavy commercial vehicles by petrol.

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE summer meeting of the Institution of Mechanical Engineers opened at Lincoln at 10 a.m. on Tuesday, the 20th inst., when the Mayor of Lincoln, Alderman H. A. Cottingham, formally extended a welcome to the President, Captain R. H. R. Sankey, C.B., and the members assembled in the Lecture Theatre of the Municipal Technical School. The Mayor, in welcoming the Institution to Lincoln, said that there was hardly a region of the world to which the products of Lincoln had not penetrated. The engineers and the Corporation in Lincoln were on terms of the most cordial relationship. Many of the leading members of the principal firms had been mayors, in the past, and the engineers of the district had always been ready to assist the Corporation; one (Mr. F. H. Livens) had done more than anyone else, apart from the city engineer, to help to provide Lincoln with a good water supply.

The President, in reply, thanked the Mayor for the hearty welcome the Institution had received. He thought the information they would doubtless gather in their meeting would be of value to the profession at large. He thought the interesting relations between the engineers and the Corporation, to which the Mayor had referred, must help both in many ways. He regretted the attendance was not greater. When the present membership of the Institution was compared with that of 1885, the date of the last Lincoln meeting, a larger meeting would have been anticipated. He was afraid railway travelling had something to do with the smaller proportion present now.

Lieut.-Colonel E. Mansel-Sympson then gave a lecture on Roman Lincoln. This proved a very interesting item of the programme, but it is rather outside the scope of our columns, and, therefore, can only be briefly referred to. The lecturer drew attention to the various features of the Roman city and to the remains still to be seen in and around the city. He also pointed out the location of the various public buildings.

RECENT EXCAVATION PROGRESS.

After a vote of thanks to the author, proposed by the President, and duly acknowledged, Mr. F. H. Livens was called upon to read the paper on "Recent Excavation Progress," which jointly with Mr. W. Barnes, he had submitted for discussion. This paper we reprint *in extenso* on page 110.

The reading of a summary of the paper by the two authors was accompanied by a most interesting series of lantern slides, and by an excellent set of cinematograph films showing excavators of the types dealt with in the paper, actually at work. This conveyed to members a much more realistic impression of this work performed than the paper taken alone. Mr. Barnes stated in connection with one machine that work done before the war by hand at a cost of 7*d.* per cubic yard was afterwards done by machine at 1¼*d.*

The first speaker in the discussion was Mr. L. A. Legros, who said he thought the paper a happy balance. It had line engravings of the details; photographs of the machines, and the cinematograph had given them a good idea of working conditions. He would like to know whether the material excavated was prepared beforehand by dynamite or blasting of any kind. Had British makers of such machinery done anything in the way of developing machinery for trenching; that line had been worked up in America to some extent.

Mr. R. S. Westwood, of the Frodingham Ironstone Mines, said he, as a user, could confirm the figures given in the paper. He thanked the authors for the work they had done in recent years in developing this particular type of machinery. The progress from the old type of steam navvy to the modern machine could only be realised by those who had to use them. Civil engineers were greatly indebted to Messrs. Ruston's who had associated themselves with every form of progress. Although these machines appeared to be as near perfection as could be expected, he looked for still better results in the future. One of their troubles was in dealing with big lumps of ore. In the 4-yard bucket of a No. 30 machine digging in a depth of 30 ft. of ironstone large lumps were often met with. He hoped some process would be devised of dealing with these without producing at the same time too much small. It was much cheaper, within limits, to mine ore by quarrying than by underground working. They regarded with concern a future when it would not pay to quarry, and they would be forced to go underground. He thought mechanical engineers would assist them in deferring that day. Some years ago a 30 ft. depth had been looked upon as the limit. He was now working 40 ft. and even 60 ft., and he thought even 100 ft. might be worked by increasing their transport facilities. If the material could be carried greater distances, he thought the greater depths might be worked. The Americans did not face the problem at all, they wagoned the material away. That was very expensive. He preferred the single or double operations dealt with in this paper. Most rock had to be shaken by explosives before excavation.

Mr. W. H. Patchell remarked that he considered the authors had given an excellent demonstration of the fact that in the cinematograph they had an uncommonly good educational tool.

The President then called upon Mr. Livens to reply. Mr. Livens said that he hoped Mr. Westwood's remarks would bear fruit. The amount of preparation to be done, of course, depended on the class of stone to be worked. In some places it was possible to do without it. In his remarks on the limits of surface mining, Mr. Westwood had opened a large problem. With increased size of machines they had to increase the means of carrying them; beyond a certain size this provision became very expensive, and this would cut into the economy which the larger machine should otherwise result in. Wagon roads etc., had to be relatively more perfect so as not to have more idle time. They would see what could be done. They had done some trenching abroad, but had not concentrated on that branch of work.

Mr. W. Barnes said he thought the large stone difficulty would ultimately be overcome by using a crusher in conjunction with the excavating machine. It was to the ironmasters' interest to get ore as uniform in size as possible, as it was then in the most economical form for his furnaces. He thought machines would tend to get larger as time went on. A few years since it was thought the minimum depth for economical working was 20 ft., now it was about 25 ft., while the maximum was about 40 ft. or 50 ft.

ROAD TRANSPORT BY STEAM VEHICLES.

The next paper was entitled "Road Transport by Steam Vehicles." It was by Mr. P. W. Robson, O.B.E., and is reprinted on page 123 of this issue.

Mr. W. T. Bell was the first speaker in the discussion. The author had made out an excellent case for the steam wagon. His figures would take a lot of getting over. It was interesting to see that the author's firm, after long experience with the over-type engine, were now taking up the under-type. The advantages appeared to be with the former, though it was difficult with that type to maintain the legal axle-weight limits and still obtain

the five-ton load; but it could be done. The author proposed to use piston valves. The Sentinel wagon had had piston valves, and these were given up in favour of the poppet type. It would be interesting, after that change, to see whether the author's design worked.

Sir Henry Fowler, K.B.E., who said he had been one of the observers in the first steam lorry trials in this country, believed that his company owned one of the largest fleets of steam vehicles. They had found them exceedingly satisfactory. His figures would not compare with those of the paper, as they were taken on a different basis. He would like to know the date for the figures given for costs. With labour conditions always changing that was important nowadays. They had just broken up a petrol vehicle bought in 1903, which had given good service. Their steam vehicles of 16 and 17 years ago were still working satisfactorily. Against the steam vehicle for some services there had to be considered the question of fire risk, which sometimes militated against them. He did not wish to discuss the railway problem. He lived on a road between two large towns on which it had become impossible to ride a bicycle with comfort. One of their greatest problems to-day was that of the state of the roads. Until they had some movement by a central authority, the roads would not be put into a condition suitable for either petrol or steam transport.

Mr. T. Clarkson said the author had focussed their attention on the steam vehicle. Road transport was largely a development of the petrol motor. Steam engineers should not be prejudiced, but should approach the subject with an open mind. Horse-traction consisted of three parts; the horse, the harness and the vehicle. Motor transport likewise consisted of the motor, the transmission and the vehicle. The transmission, &c., had now reached a high degree of efficiency. He agreed that steam vehicles would handle the heavier classes of traffic of the future (10-ton loads, &c.); he would go further, he thought they would handle much of the lighter traffic. The very success of the petrol vehicle had been its ruin. It was multiplying so fast that it would soon more than absorb the possible supply of petrol. The price of petrol might soon go up to 5*s.* or 6*s.* per gallon. By the end of the year they would be paying probably 10*d.* per mile for petrol alone per lorry. Another fuel would have to be found. Alcohol had been suggested as the solution, but they had other and cheaper fuels. For instance, creosote might be used, and at present prices would work out at about 3*d.* per ton-mile. He had also had a good deal of experience with hard coke used with the dust removed. That worked out at about 6 lb. per mile, or at present prices 1½*d.* per mile. There was nothing to touch it. Features of the petrol machine might with advantage be combined with motors using other types of fuel.

Mr. L. A. Legros said the vehicle and road should not be considered apart, but as together making one unit. He would ask what would have happened if the railways had been placed under the canals. Would the roads ever be developed if they are placed under the railway people as had been now done in this country. He would like the author to state what tyres were used in the vehicles mentioned in the paper. That had an effect on the vehicle and also on the roads, especially if the latter were put into a state of dustlessness and freedom from water penetration. The steam vehicle had made three attempts to come into existence, and had only achieved success on the third effort. The petrol vehicle was comparatively young. The steam vehicle had had all the advantages of other practice which had assisted in its development.

Dr. H. S. Hele-Shaw said he had long considered that heavy loads would be an important factor of road transport of the future. Now the question of fuel was a most urgent one. The United States, which supplied all our fuel, had over-reached itself. It had wasted millions of tons of liquid fuel, and next year would be compelled to import one-seventh of its requirements. When they had looked into the question some years ago people had taken little note of it. Now the pinch was beginning to be felt. They were faced with a serious problem. It was clear that the end of liquid fuel was going to be immensely more rapid than the end of coal. He wished to pay a tribute to Mr. Clarkson, who had so long fought the battle of the steam vehicle. Later facts had shown that Mr. Clarkson's work had been much nearer the point than might have appeared in the past. It was a great credit to British engineers that early steam vehicles were still running. For good work Lincoln had always had a high reputation.

Captain G. H. Savage said he thought some mention should be made of Colonel Smith's vehicle using suction gas produced in an anthracite-burning producer. It was described in the technical journals recently.*

The author, in reply, said the chief object he had had in writing the paper was to bring out (1) that the supply of petrol was in jeopardy, and (2) that road transport was a necessity of modern life. They had become accustomed to road transport through the petrol vehicle. Though the petrol supply was in danger, road transport was not, owing to steam. The over-type of machine could be brought within the legal limits all right; the advantage of the under-type did not rest on that. For long distances the over-type was good. If the roads were good and the grades not too heavy the under-type had a large sphere of usefulness. He looked for developments in the lighter class of vehicle. Mr. Clarkson might have found the solution in that direction. The roads were a large problem, but it was second to the problems forced upon them by the shortening of hours. That had produced one of the biggest revolutions that had ever been faced. The time element and the short day was going to decide what should and what should not be used. The roads in the end would have to be accommodated to the new forms of traffic. His experience was that fire risk was comparatively seldom the decisive factor as between machines. The suction-gas machine was too new a development for him to say much about.

The meeting then adjourned, various visits being paid in the afternoon to works such as those of Messrs. Clayton and Shuttleworth, Messrs. Robey and Co., and Messrs. Clarke's Crank and Forge Company. At the two former members were entertained to tea. These two works have been dealt with at length recently in our columns, and we need not, therefore, refer to them further now, except to say that members greatly appreciated the arrangements made at all works for their entertainment.

Institution Dinner.

The Institution Dinner was held in the evening at the County Assembly Rooms.

(To be continued.)

* See ENGINEERING, vol. cix, p. 59.

NOTES.

The Present Position of the Shipbuilding Industry.

From the Lloyd's shipbuilding return for the quarter ending June 30 last it appears that in all 2,195 merchant vessels with an aggregate gross tonnage of 7,720,904 are in course of construction, of which the United Kingdom is responsible for 941 ships aggregating 3,578,153 gross tons. This latter figure represents an increase of 184,000 tons as compared with the return last March, and an increase of 1,054,000 tons as compared with conditions a year ago. The largest increase has been at the Clyde shipbuilding centre, where 1,260,777 tons are now under construction. The corresponding figure for the North-East Coast area is 948,209 gross tons. The new tonnage commenced during the past quarter represented 588,604 gross tons, and a noteworthy feature is the large average size of the vessels in demand. There are now building 223 vessels of 6,000 tons or over, as compared with 210 in March. The vessels of 10,000 tons and upwards number 63. Whilst there has been, during the quarter, an increase of 184,000 tons in the work under construction in British yards, there has been a large fall in the work in hand abroad, although it should be observed that the returns include no figures for Germany. The most notable drop in production has been in the States, where the decrease has been continuous for the past 15 months. In March, 1919, the work in hand at American yards was 4,185,523 gross tons, on June 30 last it was 2,105,956, whilst in the United Kingdom the merchant tonnage in hand has increased 60 per cent. during the same period, and is now a record for this country. During the quarter the tonnage in course of construction in the Overseas Dominions has increased by 36,000 tons the aggregate at the end of June being 268,799. Holland also shows an increase, but in Japan the tonnage under construction has fallen by 31,000 gross tons. It is interesting to compare present figures with those for the second quarter of 1914. Lloyds returns for that date showed a world aggregate of 3,162,890 gross tons, of which 1,722,124 tons were being built in British yards.

Fatigue and Efficiency.

A paper was read at the recent meeting of the Royal Sanitary Institute at Birmingham by Dr. E. L. Collis on the connection between industrial efficiency and fatigue. Much of the paper was of a general character dealing with the question from the medical aspect. The author's view of the relation between fatigue and efficiency is that there are two opposing influences at work. In the first place, since practice makes perfect, the repetition of movements tends to make successive movements easier. On the other hand, nervous fatigue intervenes after a time, and tends to inhibit the transmission of directions to the muscle from the controlling centre in the brain. The muscle concerned is willed to contract but fails to respond, although the brain is as active as ever, and by direct stimulation of the muscle the latter can also be proved to be still active. In short, the failure to respond has, Dr. Collis states, been traced to a sort of "sub-office" in the spinal cord which refuses to pass on to the muscle the instructions received from headquarters. This "sub-office" thus constitutes a defence against exhaustion of the muscle. If the latter be given a little rest it will again respond, "the block on the line" having been removed. Fatigue originates, therefore, in the nervous system and not in the muscles. Hence activity is associated at the outset with a period of increasing efficiency due to practice, and this is followed later on by a period of diminished efficiency due to the block imposed by the nervous system. When the physical strain is not too great, or the hours of labour not too long, efficiency improves continuously throughout the hours of employment. The week-end rest serves to promote recovery from fatigue, but some practice is lost, and here it is suggested is to be found one reason why Monday is commonly a day of diminished output. If the week-end rest has been insufficient the effects of fatigue overbalance those due to further practice quite early in the week and the output falls off. Similarly with unsuitable hours of labour the afternoon production may show a lower average than do the morning hours. Dr. Collis further observes that the worker ought to be selected for the work, and that if this were done some economic losses would be avoided. He states, that as matters stand, to maintain a staff numbering 1,000 it is frequently necessary to engage 1,000 new workers per annum. Were workers selected for the work according to their natural aptitudes he claims that a very large reduction would be made in the constant necessity of engaging new hands. In this connection, as in other portions of his paper, we regret to find no reference to the work of that remarkable man, the late Mr. F. W. Taylor, who was the first to show that by compelling men engaged in arduous labour to take frequent intervals of rest the output per head was enormously increased. He further emphasised the importance of selecting the worker for the work in hand. As he put it, he had little use for any but a first-class man, but he had hardly ever, he said, met with a man who was not first-class in some department of work. These views, it will be seen, are in very close accord with those advocated by Dr. Collis, and it is fitting that due credit should be given to the original pioneer and discoverer.

ROAD TRANSPORT BY STEAM VEHICLES.*

By P. W. ROBSON, O.B.E., of Lincoln.

1. *The Permanent functions of Road Transport.*—It may be stated as an axiom that the methods of transport of goods have recently undergone permanent changes of a far-reaching character. Shorter working hours and diminished output of work per man have introduced a disturbing factor in the handling of goods traffic on railways which demands a fundamental remedy. That remedy will doubtless be of a many-sided character, involving those larger and changed types of railway trucks, and those different methods of railway working about which one has heard from various railway authorities. But the higher cost of labour at the terminals, the reduced number of hours during which distribution from the terminals can take place, and the equally reduced number of hours at the works and warehouses during which goods can be received—all of these things mean that the pre-war conditions for the transport and general distribution of goods and merchandise can never return in the old form.

It is these changed conditions which have brought about the greatly extended use of road transport, and it follows that its increasing application is not a temporary or accidental by-product of war conditions, but is the direct and logical outcome of shorter working hours, and the granting of increased wages to general transport workers, both of which have made inadequate, and impossibly costly, the pre-war method of terminal working at the goods yards, and the distribution of goods therefrom.

In whatever manner rail transport may be improved in future, the use of road transport vehicles must continue to extend, because, first, there must be well-defined limits within which the costs of the secondary operations of transferring goods from works or warehouse to the goods yard, the handling at the goods yard, possible transference en route, with a converse series of operations at destination, far outweigh the cost of the primary operations of transport by rail from town to town. Within these limits, motor transport will be employed increasingly. Secondly, the shorter working hours in factories generally make it impossible to accept the serious and inevitable delays incidental to the secondary operations referred to. Now, as never before, "time is money," and rail transport will be judged in future not only on the basis of its net cost, but also in relation to the time occupied in passing goods from point of despatch to destination. If the time occupied is too long in sending by rail, a higher transport cost will be justified by a sufficient saving in time.

It follows that a stage has been reached when road transport vehicles must not be regarded merely as accessories to the business of the private user, valuable though they are from this standpoint. They must be recognised as the only solution whereby railways in this country can be worked efficiently under the new conditions which have been imposed; for it is by the organised use of road transport only that the congestion at the rail terminals can be reduced, whereby railway labour can be used more efficiently, railway wagons released, and a scientific re-organisation of the railway system made possible.

When the whole question of road transport is approached from this wider point of view, it will be realised at once that the problem has not to be solved only in relation to the requirements of the private user who acquires a road wagon for the speeding up of his business; it becomes a question also of its scope and application as a means of handling economically a maximum tonnage over a maximum distance on a regular and organised service. The alternative forms of road transport wagons should be judged impartially in relation to these aspects of the problem, and each allocated to the functions it can best perform, so that the highest general efficiency is secured.

2. *The Economics of Steam Vehicles.*—The object of this Paper is to emphasise the usefulness of the steam motor-wagon as the most economical and reliable form of road transport. In making this statement, however, the claims of the petrol and the electric vehicle respectively are not overlooked. Each has its sphere of advantageous application. Just as in the generation of power, the steam-turbine, the gas-engine, and the oil-engine have their proper and recognised spheres of usefulness, so it is with these three forms of road vehicles, whose respective provinces fall into such relation as not to conflict the one with the other.

For transporting a maximum tonnage over a maximum distance in a minimum time at minimum cost, the steam-wagon takes an easy lead over its rivals. For maximum mobility with lighter loads, and for special suitability for intermittent work, the petrol-vehicle has undisputed claims, though its working costs are necessarily higher than in the case of the steam-wagon. The electric vehicle will be applied increasingly for town work and for short distance haulage. There is, of course, a dividing line between the respective spheres of these three forms of road transport, and on those dividing lines it may be a little difficult to come to a clear decision as to which side to incline towards, but such cases are in the minority; in the great majority of cases given, a clear understanding of the conditions that have to be met, and the decision as to choice of type to be applied, follow as a matter of course.

Having made the statement that steam haulage is the most economical form of road transport, it is necessary to give facts which will support it adequately. With this object, the Author recently caused careful investigation to be made by a trained staff into actual running costs of various types of steam and petrol motor-wagons operating in the service of road transport firms and private users who have adopted motor transport over a considerable number of years, and who have made an experienced study of working costs. Figures have been analysed which represent, in the aggregate, 15,000,000 ton-miles hauled. The capacities of the vehicles examined vary between 3 and 6 tons, and to obtain an accurate comparison, each performance has been adjusted to give the cost of hauling 5 tons over 1 mile.

Analysis of Costs.—Table I shows the costs in six instances of steam vehicle haulage and nine cases of petrol-vehicle haulage, representing approximately the work done by 100 steam lorries and 100 petrol lorries.

Table II is an example of how the costs on Table I were arrived at for vehicles A and H. The mean load of the steam wagon A was 6 tons, and that of the petrol H was 5 tons. These were chosen as typical heavy-duty vehicles working under very good conditions of loading, &c. The items "Fitters and Spares," "Coal," "Oil," "Tyres," were obtained from the owners as the actual costs booked to the wagons, whilst the other items were inserted as standard present-day costs, and were applied equally to all vehicles except when total costs as supplied by the owners included these.

Recent alterations in rates of wages have been taken into account so far as is possible. A 10*s.* per week rise for each of two men is less than 1*d.* per 5-ton mile.

The investigation covered the performance of 100 steam vehicles by five different makers of note, and also 100 petrol vehicles by nine leading makers. The costs given include all overhead charges, depreciation, interest, fuel, wages, repairs, &c., and have been obtained from actual wagons on every-day commercial work, and are not makers' tests. To avoid any suggestion of preferential treatment for steam-wagons the depreciation of both petrol and steam vehicles has been taken equally on the basis of 12½ per cent., although it may be fairly claimed that the depreciation of the latter is very much less than the former. There are many steam wagons 10 years old and over in constant and reliable service at the present time, and the City of Westminster has to-day three steam wagons in regular service which are all 20 years old, and have been in commission for the whole of that period.

TABLE I.—*Comparative Costs of Hauling 5 Tons per Mile by various Steam and Petrol Wagons.*

Average annual capacity of one 5-ton wagon = 75,000 ton-miles. These costs, include all overhead charges depreciation, interest, fuel, wages, repairs, &c., and are obtained from actual wagons at work (not on test).

Average costs by steam to carry 5 tons 1 mile = 1/5½.
" " " petrol " " " " = 2/10½.
Showing annual cost saved by each steam wagon compared with petrol to be over £1,000.

NOTE.—The above costs have been attained from records kept by hauliers, &c., and cover the haulage of over 15 million ton-miles.

*** Since compiling the above, the price of coal has advanced 14*s.* 6*d.* per ton, which adds approximately 1*d.* to the cost per ton-mile. The annual saving is thus reduced to £950.

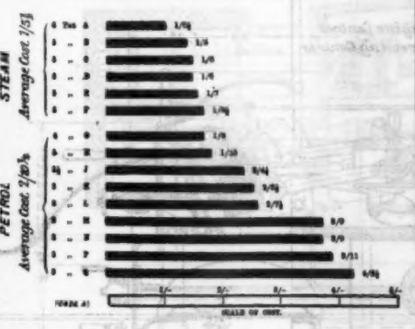


TABLE II.

This Table corresponds to vehicles A and H on Table I, thus :—

—	Typical Steam Vehicle (A).	Typical Petrol Vehicle (H)
	£	£
Depreciation ..	180	180
Interest	70	70
Fitters and spares ..	188	145
Fuel	90 tons at 35*s.*, 170	3,000 gals. at 5*s.*, 2½*d.* 480
Oil	250 gals. at 5*s.*, 62	170 gals. at 5*s.*, 42
Wages (man and lad)	430*	340
Tyres	105	80
Insurance ..	20	20
Accommodation ..	20	20
Total costs ..	£1,245	£1,377
Mileage ..	20,000	15,000
Cost per mile ..	1*s.* 3*d.*	1*s.* 10*d.*
Cost per 5-ton mile	1*s.* 0½*d.*	1*s.* 10*d.*

* Higher wages due to longer hours.

Special note on increased cost of coal since this Paper was written :

Extra cost due to 14*s.* 6*d.* per ton increase in cost of coal is approximately 1*d.* per mile, bringing cost of steam-wagon to 1*s.* 1½*d.*

The result of this investigation, which it is believed to be unique in its scope, is as follows :—

Cost of Hauling 5 tons over 1 mile.

	s.	*d.*
Steam vehicles	1	5½
Petrol vehicles	2	9½

Annual saving over 15,000 miles by use of steam against petrol vehicles } £1,000 per vehicle.

As stated above, these figures represent the actual total cost, and include :—

Interest ... ... } On a common basis per vehicle.
Depreciation ... ... }

Repairs and spares ... }
Fuel... ... ... }
Oil ... ... } Taken from actual records for each vehicle.
Wages ... ... }
Tyres ... ... }

Insurance ... ... } On a common basis per vehicle.
Garage accommodation ... }

Three hundred miles per week, or 15,000 miles per annum, is taken as a reasonable performance for a commercial vehicle in an organised service run for profit. Several interesting and significant facts transpired from the investigation. It was found, for instance, that whilst the average performance of each type of steam-wagon gave steadily consistent figures, those in connection with petrol lorries varied very widely, and it would seem in consequence that they are more sensitive to varying factors in running conditions and also in the state of their repair and general adjustment. In the case of petrol vehicles, experienced large users were found to be convinced that the costs of upkeep and repairs in the 30-cwt. to 2-ton types were almost as heavy as in the 3-ton and 4-ton lorries, and hence when a reasonably full mileage per annum has to be traversed, the saving in the use of steam wagons, when all costs are taken into careful consideration, is even more marked on the lighter loads.

3. *Carrying Capacity.*—Steam wagons are normally of from 5 tons to 6 tons capacity, a 3-ton type being also employed to a lesser degree. The standard 5 ton to 6-ton type regularly carries its full load, and when the local authorities allow increased axle-loads, they are loaded up to 8 tons and 10 tons. In addition, they often haul a trailer loaded with 3 tons to 4 tons, so that, on long journeys, wagon and trailer regularly transport from 8 tons to 10 tons per journey with two men. This performance as a regular commercial proposition is altogether beyond the scope of standard petrol motors. The ability of the steam wagon to transport these heavy loads successfully gives it a great advantage on a regular service where a large tonnage has to be moved.

To sum up the economic aspect of the subject, it will be clear from the facts here presented that a strong case is made out for a much wider application than hitherto of the steam motor wagon for all kinds of loads. Its relative economy and reliability is so great as to provide ample inducement for engineers and manufacturers to devote time and study to its further development and improvement.

4. *Steam Wagon Construction.*—There are three well-defined types as follows (Fig. 1) :—

(*a*) The Over-Type, as made by Foden, Clayton, Garrett, and others.

(*b*) The Under-type, as made by Sentinel, Clayton, Atkinson and others.

(*c*) The High-speed Engine type, as in the National steam car, designed by Clarkson, and familiar through its application to the London steam omnibuses.

A brief review of the salient features of these three distinctive types will serve to show the present position of steam motor wagon construction.

The Over-Type Wagon.—The over-type wagon is a direct development from the ordinary steam traction engine. It derives its name from the manner in which the engine is mounted on the locomotive type boiler, Fig. 2, the boiler itself being, in fact, the engine frame. The engine, is compound the cylinders being usually of the following dimensions :—

High pressure cylinder, 4 in. diameter ... } Stroke 7 in.
Low-pressure cylinder, 6½ in. diameter ... }

The cylinders are steam-jacketed, the jacket serving as a dome to the boiler, and it therefore carries the safety valve. The steam regulator valve is also suitably mounted in the cylinder-casing, and is so arranged as to admit live steam to the low-pressure cylinder when required. There is likewise a diverting cock in the intermediate receiver, by which means both cylinders can exhaust direct to the atmosphere when each is working with live steam. The engine, therefore, normally works compound, but for quick acceleration after stopping in town traffic, a convenient movement of simple levers brings the double high-pressure into action. The crank-shaft carries fast and slow speed pinions which gear into spur wheels on a second motion shaft. These spur wheels carry the chain sprocket which drives the rear axle through a roller-chain connection.

The distribution valves to the cylinders are either ordinary flat D valves or piston valves operated by Stephenson link motion. The front-axle steerage is usually of the form in which the axle itself turns on a centre pivot, the movement being controlled by a cabin operating gear. There is a live back axle, and in the best practice each rear wheel is fitted with an expanding brake controlled by the foot of the driver. Robustness and accessibility, with corresponding reliability and ease of repair, are the outstanding features of this vehicle. In former days when steel tyres were invariably used, it is not too much to claim that the over-type wagon was the only type which gave satisfactory service, and it has done more than any other to maintain the confidence of users in the formative years during which

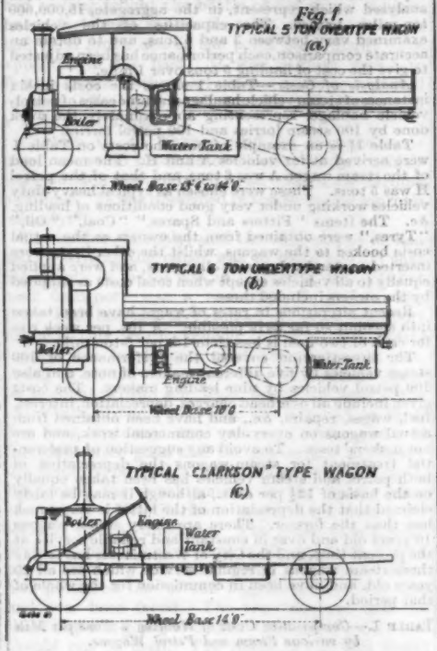
* Paper read before the Institution of Mechanical Engineers, at Lincoln, July 20, 1920.

road transport has been developed to its present stage, now when all types of steam wagons are mounted on rubber tyres, the greater margin of strength and reliability which the over-type wagon has always possessed still remains in reserve, and for continuous work in the hands of the ordinary driver, and for use on indifferent roads, it has no equal.

On the other hand, in this type of wagon the wheel-base is necessarily longer than in the alternative under-type, owing to the form of boiler and arrangement of mechanism, and in the rough and tumble of commercial propaganda this comparison is usually enlarged upon unduly so as to discredit the over-type. As a maker of, and a strong believer in, both types of steam wagon, the author deprecates this tendency, for both have ample scope and innumerable spheres of work, and each has distinctive merits.

The Under-type Wagon.—This wagon is so-called because the engine is quite separate from the boiler, and is fixed to the chassis underneath the body of the wagon. A vertical cylindrical boiler is adopted invariably with central furnace in which water tubes are introduced. A super-heating coil is inserted in the upper part of this furnace and the whole of the steam is dried and superheated on its way to the engine. As the latter is placed under the body of the wagon, and is, therefore, not conveniently accessible, the utmost simplicity is desirable. In consequence, compounding and the two-speed gearing are dispensed with. The engine is made larger and more powerful, and to provide for the wide variations of power required for running on the level, and for hill climbing respectively, some suitable form of variable expansion gear is desirable. The Sentinel engine has drop valves actuated by cams. The camshaft is arranged to slide axially under control from the driver's operating gear, and in this way cams with profiles suitable for early and late cut-off in the ahead direction of rotation, and for reverse are respectively brought to operate on each set of valves at the will of the driver. In the Clayton under-type a larger engine, Fig. 3, is employed, Table III, fitted with piston valves operated from eccentrics mounted on a lay shaft. A special device of great simplicity is used to control the angle of advance and throw of the eccentrics, so that a full range of cut-off from zero to maximum is under the control of the driver as shown in Fig. 4 and Fig. 6. By the same means the eccentrics are brought into the reverse position, it immediately acts as an air compressor pumping compressed air into the intermediate steam pipe between stop valve and engine; a relief valve is fitted to this pipe which can be opened by a pedal under the control of the driver so that the back pressure can be relieved when the braking effect is too great. With this convenient arrangement, the expanding rim brakes on the rear road-wheels are seldom required. The sprocket on the end of the crankshaft, driving on to the live back axle with a roller chain constitutes the complete transmission system.

Fig. 1.



Indicator diagrams showing the effect of notching up the valve-gear of the Clayton under-type wagon are shown in Fig. 5.

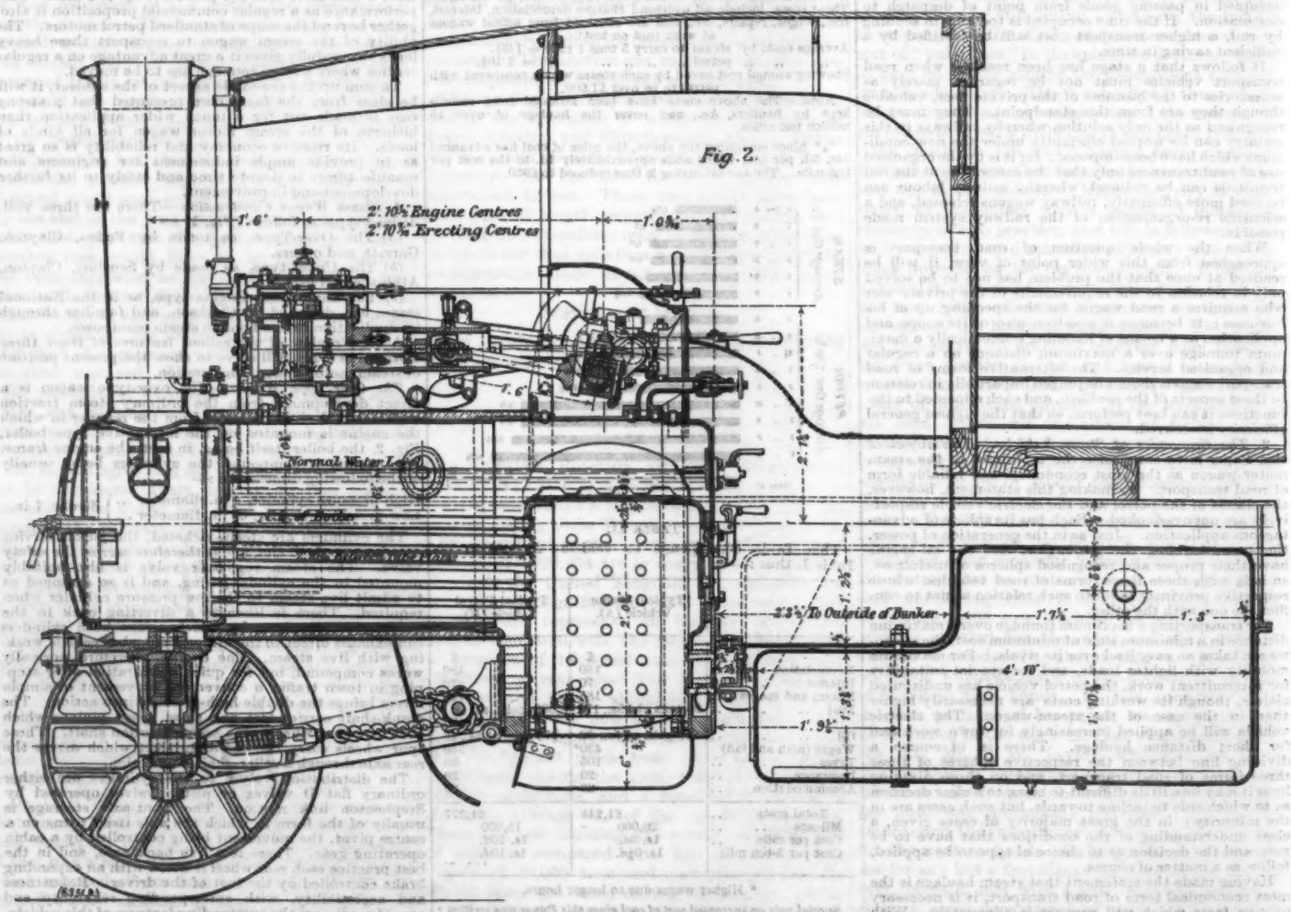
The Sentinel cross-tube boiler illustrated in Fig. 7 is well known*. In the Clayton boiler, Fig. 8, it will be seen that a corrugated furnace is adopted with a special double set of curved water tubes projecting into the furnace gases in a vertical plane; each tube has an equal chance of deriving heat from the furnace and, being arranged vertically, the circulation and evaporative efficiency are correspondingly improved. The elasticity of both furnace and tubes enables the boiler to be forced without the slightest danger, and the improved circulation keeps the tubes clear of deposit.

The steering is by pivoted wheels on a fixed front axle. It will be seen from the Figs. that the style of boiler and arrangement of under-type engine enables a short wagon to be constructed without reducing the size of loading platform. When mounted on rubber tyres and used on first-class roads without too many gradients, the under-type wagon is most suitable, and it is being employed increasingly in this connection.

The choice as between over-type and under-type must be regulated by the conditions which have to be met. In the case of the individual user who has one or two wagons and where the driver has to do his own repairs, the inherent advantages of the over-type with its open engine and accessible mechanism, coupled with its simplicity and strength, constitute a powerful recommendation; also for hilly or rough roads or for combination with trailers it has a distinct and proved advantage. Speaking generally, the 5-ton over-type may be claimed as a universal machine. On the other hand, for maximum distances on first-class roads the under-type may be applied advantageously. Both types will have their proper uses for many years to come.

High-speed Engine Types.—Mr. Clarkson, whose name is associated with the development of the steam omnibus which, until recently, was so well known on the London streets, has given much time and thought to the production of a 3-ton steam lorry, which differs radically from the vehicles which have been already described. The essential difference is that the engine (for dimensions of which see Table III) is of the compound type with

Fig. 2.



In both the Sentinel and Clayton wagons the engine is used as a brake when running down gradients; the valve gear is brought into the reverse position, and as the engine is running ahead with the steam shut off, cylinders arranged V fashion having connecting rods coupled to a single crank. Each cylinder is fitted with a

* See Proc. I. Mech. E., 1919, Figs. 46-47, Plate 26.

TABLE III.—LEADING DIMENSIONS OF TYPICAL WAGONS. YEAR 1920.

Name of Vehicle and Makers.	Net Load.	Engine. Bore and Stroke.	Engine. B.H.P. at Normal Speed.	Type of Boiler.	Fuel. Recommended.	No. of Speeds.	Final Drive.	Type of Wheels.	Size and Type of Tyres.	Track, Centre to Centre. Front.	Track, Centre to Centre. Rear.	Wheel Base.	Length Overall.	Length Body Space.	Tare Weight, Chassis.
	Tons.									ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	
Clayton over-type	5	4 in. and 7½ in. × 7 in. stroke.	35	Loco.	Coke or coal	2	Roller Chain	Cast Steel	Rubber 720 × 160 850 × 160 T.	4 0	5 10½	14 2	21 6	12 0	4 tons 18 cwt. 3 qr.
Clayton under-type (Fig. 1b.)	6	2 h.p. cylinders 7 in. × 10 in. stroke	35	Vertical water-tube	Coke or coal	1	Roller chain	Cast steel	Rubber 720 × 160 850 × 160 T.	5 6	5 11	10 0	19 9	14 0	4 tons 15 cwt.
Foden over-type	5	4 in. and 6½ in. × 7 in. stroke	35	Loco.	Steam-coal	2	Chain	Cast stee	Rubber 850 × 160 1050 × 160 T.	4 0	5 11	14 2	23 0	12 0	—
Garrett over-type	5	4 in. and 6½ in. × 7 in. stroke	35	Loco.	Coal	2	Chain	Cast steel	680 × 140 870 × 160 T.	4 6	6 3½	13 4	22 2	12 0	—
Mann over-type	5	4 in. and 6½ in. × 8 in. stroke	30	Loco.	Coal	3	Chain	Steel	Rubber 850 × 160 1070 × 160 T.	3 5	5 4½	12 5	21 2	12 8	5 tons
Sentinel under-type	6	2 h.p. cylinders 6½ in. × 10 in. stroke	35	Vertical water-tube	Coke, steam-coal or both	1	Roller Chain	Cast steel	730 × 160 850 × 160 T. fitting	5 5	5 11	10 4½	20 6	14 6 overall	4 tons 19 cwt. 3 qr.
Clarkson high-speed engine type	3	3½ in. and 6 in. × 4 in. stroke	—	Vertical thimble	Coke	2	Worm-gear	Cast steel	—	5 10	5 6½	14 0	19 6	—	—

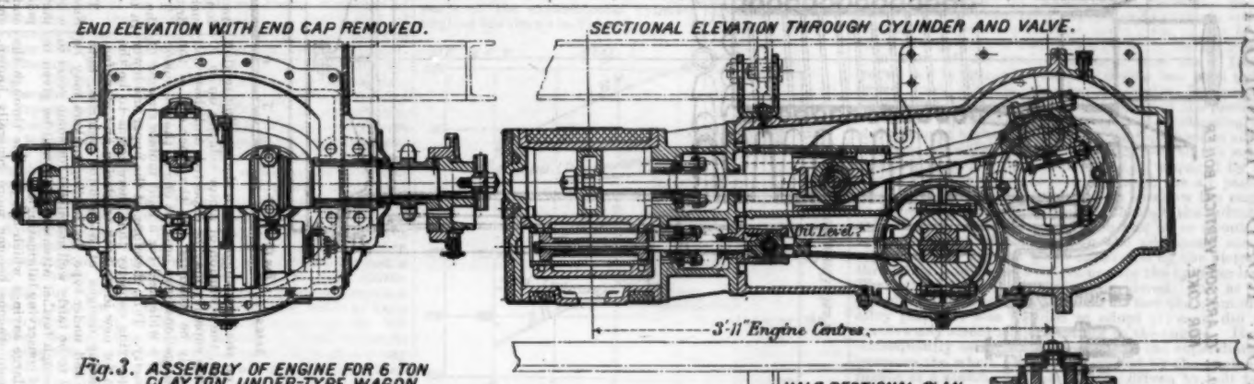
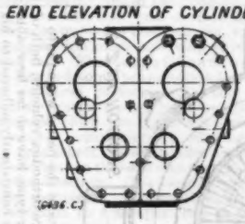


Fig. 3. ASSEMBLY OF ENGINE FOR 6 TON CLAYTON UNDER-TYPE WAGON.



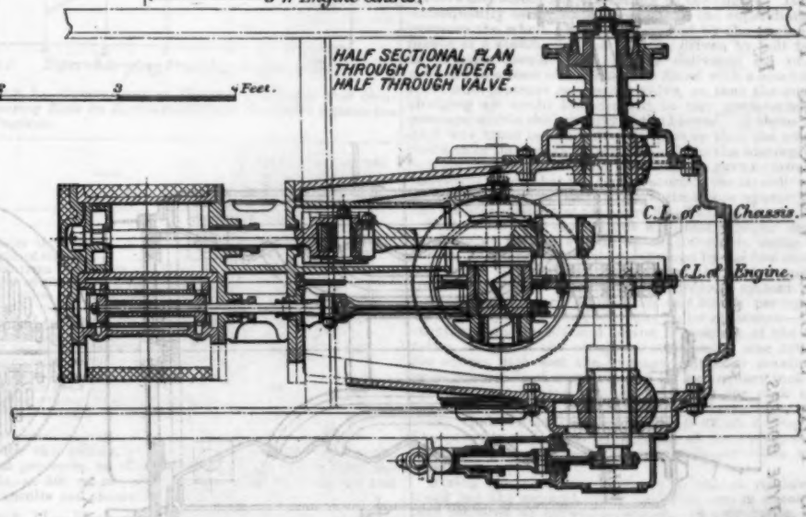
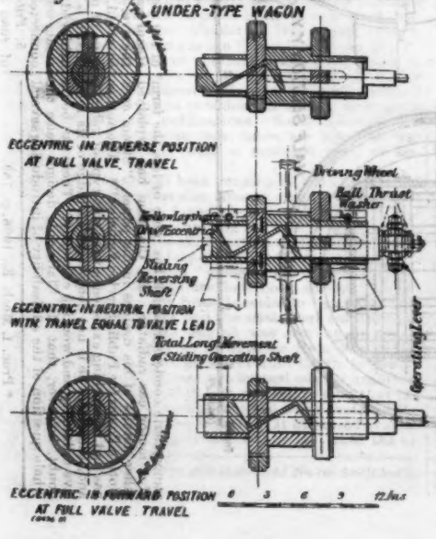
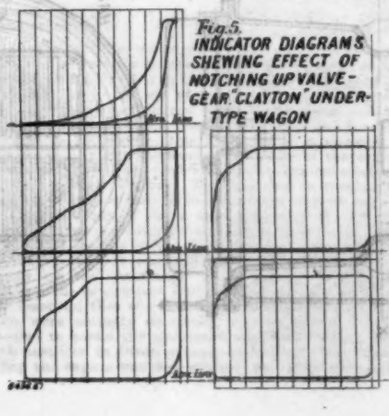


Fig. 4. ECCENTRIC REVERSING GEAR "CLAYTON" UNDER-TYPE WAGON


ECCENTRIC IN REVERSE POSITION AT FULL VALVE TRAVEL
Driving Wheel
Ball Thrust Washer
Roller Layshaft Bearing Eccentric
Sliding Reversing Shaft
ECCENTRIC IN NEUTRAL POSITION WITH TRAVEL EQUAL TO VALVE LEAD
Total Longl. Movement of Sliding Eccentric Shaft
Operating Lever
ECCENTRIC IN FORWARD POSITION AT FULL VALVE TRAVEL
6 3 0 3 12 Ins



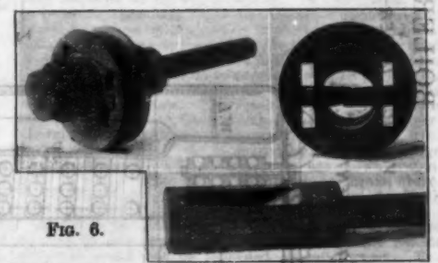
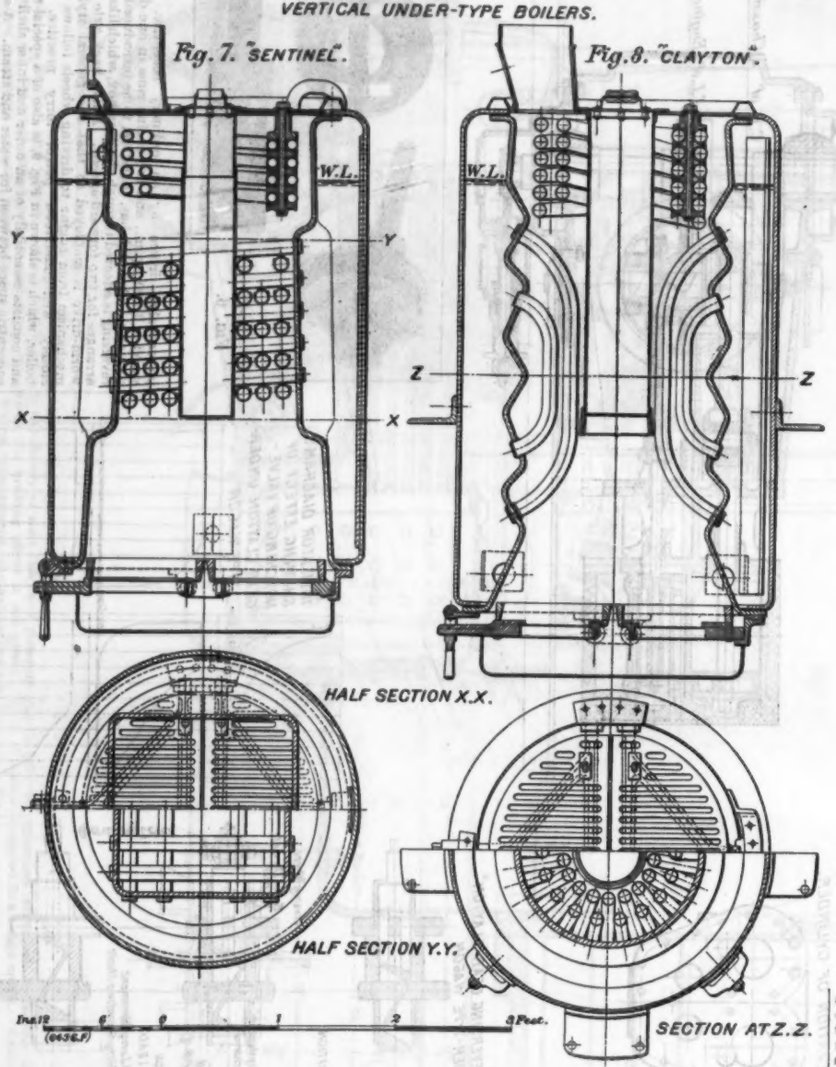


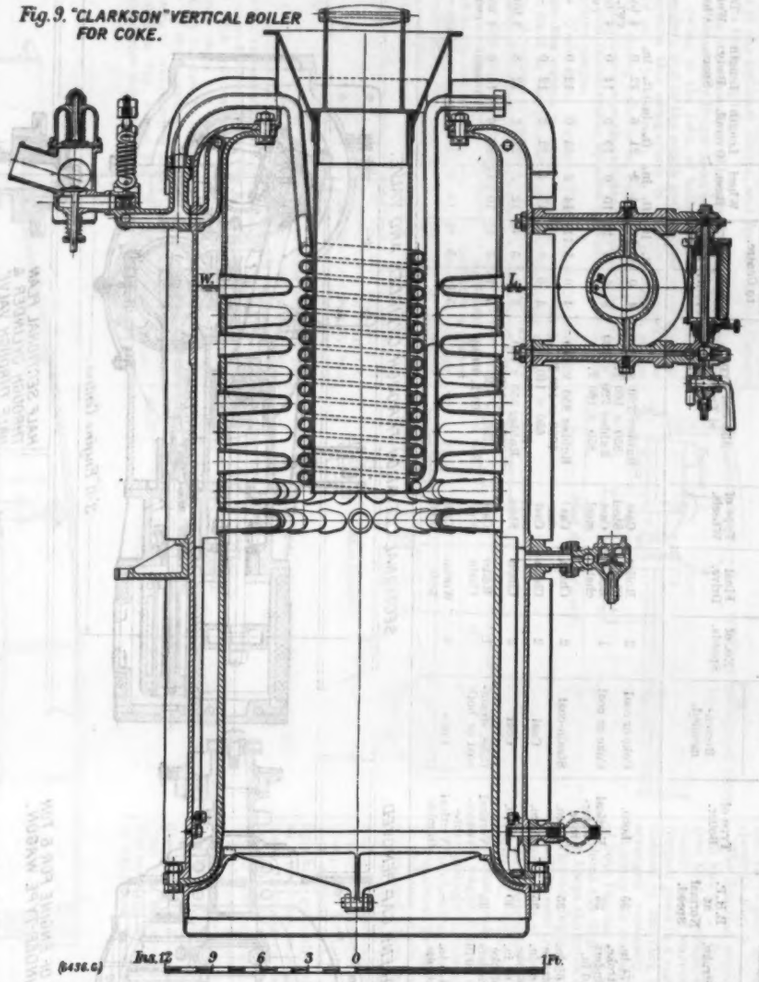
FIG. 6.

piston-valve driven by an ordinary eccentric. The speed is 1,200 r.p.m., and the engine runs in one direction only. A clutch has, therefore, to be introduced and reversing is effected through the gear-box, which likewise arranges for two forward speeds. A live back-axle with worm-drive is employed so that the general style of mechanism from engine to driving wheels follows very closely well-understood petrol lorry practice. The boiler, which is shown in Fig. 9, is also of a special type, and consists essentially of an outer and inner shell with concentric space between for water and steam. A series of solid-ended tubes project like spikes into the hot furnace gases, and these have been found to keep free from deposit. The exhaust-steam is condensed in an

BOILERS FOR STEAM VEHICLES FOR ROAD TRANSPORT.

VERTICAL UNDER-TYPE BOILERS.





atmospheric condenser which has more or less the form of a motor car radiator. Mr. Clarkson has explained other details of his designs in his paper, "Steam as a Motive Power for Public Service Vehicles."* The author has had no working experience with this type of vehicle, and, therefore, he is not competent to judge of its relative reliability and working efficiency. There can be no doubt, however, that Mr. Clarkson's designs raise the whole question of the advisability of introducing several of the most vulnerable points of the petrol wagon into a steam wagon which the more orthodox vehicles, both of the over-type and the under-type, have so far been able to avoid. Mr. Clarkson has consistently adhered to his type of machine for a good many years now, and much credit is due to him for the practical success he has achieved, and the future application of his type of steam wagon will be watched with keen interest by those connected with the industry.

5. *Future Development.*—If the permanent functions of road transport come to be regarded by those in authority on the lines suggested in the opening section of this paper, the evolution of motor vehicles up to 10 tons carrying capacity may be expected, and these will most certainly be steamers. At the other end of the scale, investigations have brought one to the conclusion that there is a wide field for a light mobile steamer of 3 tons capacity. It is, therefore, at the upper and lower limits of carrying capacity that there seems to be the most room for new ideas both on design and manufacture. Existing designs of 5 to 6-ton vehicles, both over-type and under-type, by leading makers may be considered to be fairly well stabilized for some years to come, although further attention may well be given to methods of conserving lubricating oil.

As the large savings which are possible through the use of steam wagons become more generally known, there will be an increasing tendency on the part of transport users to apply them; everything that can be done to reduce the consumption of costly imported fuel, such as petrol, is worthy of the skill and application of British engineers.

The author desires to acknowledge with sincere thanks the assistance rendered to him by Mr. H. L. Wimbush in the preparation of this paper.

* Proc. I. Mech. E., 1906, p. 753.

THE FINANCIAL POLICY OF SWEDEN.—According to *Swedish Expert*, the Swedish Government has appointed a commission to institute a thorough enquiry for the purpose of laying down the main lines of Swedish financial policy. The enquiry is to be carried out promptly; and the commission includes both theoretical economists and practical bankers, and also representatives of manufacturers and consumers.

SOME EXPERIMENTAL WORK IN CONNECTION WITH DIESEL ENGINES.*

By Engineer-Commander C. J. HAWKES, R.N. (ret.) Member.

THE object of this paper is to place before the members of the Institution an outline of the experimental work carried out at the Admiralty Engineering Laboratory in connection with internal-combustion engines for naval purposes, with special reference to the design and performance of a single-cylinder engine of comparatively large power.

In 1916, as the result of the representations of the Board of Invention and Research, it was decided to establish an engineering laboratory on a small scale, the work, at first, to be confined to experiments with internal-combustion engines. A portion of the Goldsmiths' Company's extension of the City and Guilds Engineering College, South Kensington, was kindly placed at the disposal of the Admiralty by the Delegacy of the college, and the premises were taken over in January, 1917. Arrangements were at once made to get a small designing and testing staff together, erect the necessary workshop, machines and design and obtain experimental plant and engines. Sir Dugald Clerk was appointed Director of Engineering Research, a position which he held until February, 1918.

The question of the material and design of pistons of submarine oil engines was referred to the Board of Invention by the engineer-in-chief of the Navy and the matter was first considered at a meeting of the Internal-Combustion Engines Sub-Committee on November 29, 1915. The author was secretary of this sub-committee. It was decided to construct a single-cylinder oil engine for experimental purposes, utilising, so far as possible, the parts of a standard submarine engine, in order to save time and also to keep down the cost. The drawings of the piston, connecting rod, bedplate and other parts not of the standard design were made at the Board of Invention, and the engine was constructed and erected at the works of Messrs. Ruston and Hornsby, Lincoln. The engine was first run without load on July 17, 1916.

Several designs of pistons were considered by the sub-committee, including pistons of aluminium alloy in two pieces and also pistons having aluminium alloy heads and suitably lightened bronze or cast-iron skirts. Eventually it was decided to commence the experiments with a piston of aluminium alloy and, in order to keep down the weight of the piston, a comparatively low copper content was decided upon. It was uncertain whether this piston would stand up to its work for any length of time, especially having in view the composition of the aluminium alloy then being recommended for pistons of aircraft engines, but it is interesting to note that the original piston is still in use and it has been run for a considerable time at comparatively high speeds and high mean pressures.

The trunk piston was divided at the gudgeon-pin centre and the two top-end bearings were carried between its upper and lower portions—the gudgeon pin, to facilitate dismantling, being at first made a driving fit into the eye of the connecting rod. This design followed a suggestion which was put forward some years before in connection with ordinary cast-iron pistons, with the object of obtaining a slightly greater gudgeon pin bearing surface. The top-end brasses, which were lined with white metal, were not adjustable. Lubrication was effected by forced feed from the crankshaft through the centre of the connecting rod and thence through channels in the hollow gudgeon pin to the bearings. The bearings were held in position by steel end plates. Six cast-iron piston rings were fitted in addition to a scraper ring, but, with the object of reducing the possible wear of the piston grooves, the width of the working faces of the rings were made ¼ in., as compared with ⅜ in. in the standard cast-iron pistons. Aluminium guards were fitted on the lines of the standard submarine engines in order to prevent lubricating oil, either from the top-end bearings or splash from the crank, finding its way to the walls of the cylinder liner. Splash guards were also fitted over the crank webs. The connecting rod was made of 30 tons to 35 tons steel and was of I-section—the connecting rods of standard submarine engines being of round section.

The diameter of the cylinder of this engine (which, for convenience, is known as the "Unit" engine) is 14¼ in., stroke 15 in., and of 100 nominal brake horse-power at 380 r.p.m. Other parts of the engine need no special mention, as they followed Messrs. Vickers' standard design, a full description of which has already been given in several technical publications. Solid injection was first used in this engine, but, later, air injection was fitted for experiments with a modified type of air-injection valve.

After the engine had been running at the full nominal load for some considerable time it was opened up for examination. It was found that the gudgeon pin was slightly slack in the connecting rod and it was decided, therefore, to modify the skirt portion of the piston so that it would pass over the foot of the rod for dismantling and thus permit a "shrunk in" gudgeon pin to be fitted.

When these modifications had been carried out the engine was transferred from Lincoln to the Admiralty Engineering Laboratory and the trials were continued in September, 1917. The engine was run at or above 100 brake horse-power at revolutions from 380 to 500 per minute and at mean pressures from 100 lb. to 140 lb. per square inch, and it was not opened out for examination again until July, 1918. It was then found that the piston was in good condition but the white metal of the gudgeon brasses had worn slightly. It appeared evident that this wear was largely due to the fact that the oil grooves had not been cut exactly in accordance with the instructions on the drawing, and this resulted in reducing the supply of lubricant to the grooves. It was also found that the brasses had hammered very slightly into the aluminium body of the piston and there was evidence that the side clearances between the connecting rod and the brasses were insufficient.

It was decided to bore the eyes of the piston larger, make new brasses of correspondingly greater thickness, with flanges at each end, and to fit more substantial keys to prevent the brasses turning in the piston—as the small keys originally fitted were found to be slack. The experiments have been continued since August, 1918, at mean indicated pressures up to 140 lb. per square inch, but it has not been necessary to make any further modifications to the piston. Whenever the piston has been dismantled it has been found in good condition, and careful gauging has shown that there is no appreciable wear either in the body of the piston or in the grooves—and, so far, there is no indication of "growth." The cast-iron cylinder liner is in excellent condition.

The weights of the aluminium alloy piston and I-section connecting rod of the experimental engine are appreciably less than the weights of the corresponding parts of the standard submarine engine, with the result that the inertia forces in the former at 500 r.p.m. are approximately the same as in the latter when running at 380 r.p.m. The comparative weights of the reciprocating and rotating parts of the experimental cylinder and the standard engines are shown in Table I.

Fig. 1.

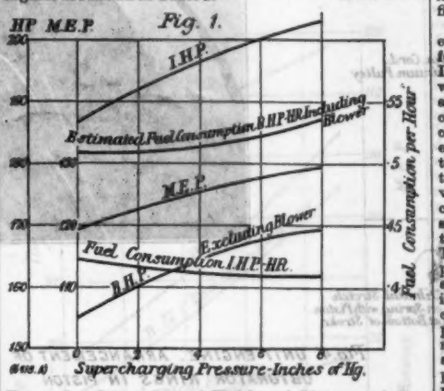


TABLE I.—*Comparison of Weights of Pistons and Connecting Rods in Experimental and Standard Submarine Engines.*

—	Experimental Engine.	Standard Submarine Engine.
	in.	in.
Cylinder diameter	14¼	14¼
Length of stroke	15	15
Revolutions per minute	380	380
	lb.	lb.
Weight of piston, with rings, bushes (in the case of experimental engine), guards, &c.	213	390
Weight of connecting rod, with gudgeon pin and large end bearing and bushes (in the case of standard engine) ..	290	423
Reciprocating weights (includes two-thirds weight of connecting rod without palm end)	510	560
Rotating weights (includes palm end and one-third weight of connecting rod) ..	193	253

With the particulars given in the above Table the mean pressures on the various bearings throughout the cycle, at 380 r.p.m., were obtained for each engine and the results are shown in Table II.

TABLE II.—*Mean Total Bearing Pressures throughout Cycle in Pounds.*

Engine.	Gudgeon Pin.	Crank Pin.	Cylinder Liner.	Main Bearings.
Experimental engine	12,320	16,200	1,420	16,200
Standard engine ..	15,250	20,260	1,840	20,260

It will be seen, as would be expected, that there is a considerable reduction in the mean total loadings of the bearings due to the use of the aluminium alloy piston and lighter connecting rod and, as the mean rubbing velocities of the various bearings are the same for both engines at 380 r.p.m., this reduction is a measure of the increase in the mechanical efficiency of the experimental engine as compared with the mechanical efficiency of the standard engine. This increase in mechanical efficiency would appear to be of the order of 2 per cent.

The coefficient of linear expansion and the thermal conductivity are greater for aluminium than for cast-iron and, in the absence of information so far as large engines were concerned, it was difficult in the design stage to decide on the clearances which should be provided between the aluminium alloy piston and the liner. It was essential that the clearances should not be greater than were actually necessary, and eventually it was decided to make the clearances similar to those usual with cast-iron in Diesel engines and to note the results. When the engine was first started, and after the engine had been running at a small load for some time, the piston seized. The piston was removed and examined, and it was found that it had been in contact with the liner over nearly the whole of its surface and the metal was scored slightly. The piston was therefore "draw filed" and replaced, and the engine again put on load. At the higher loads there was a slight seizure and again the body of the piston was filed where it had been bearing hard on the liner. Since that time, although the engine has been running at high speeds, &c., no further seizures have taken place. From the experience gained it may be taken that the clearances required with an aluminium alloy piston should be about 50 per cent. greater than the clearances necessary with a cast-iron piston. Should a cast-iron piston seize it generally results in damaging the liner as well as the piston, but in the case of the aluminium alloy piston it was found that a seizure did not damage the surface of the liner in any way. Further, it was found that as soon as the engine had cooled down slightly after a seizure the aluminium piston was quite free.

There is no doubt, so far as present experience is concerned, that aluminium-alloy pistons, although slightly greater in first cost, have many advantages over cast-iron pistons. Further experience will shortly be available as to their behaviour under actual service conditions and it will then be possible to decide whether their extended use for submarines is justified. In the meantime other Admiralty experimental engines, including the two-stroke cycle type, have been or are to be fitted with pistons of aluminium alloy for further test.

In view of the results obtained with the "Unit" engine it was decided, when the engine had been transferred from Lincoln to the Admiralty Engineering Laboratory, further to test the capacity of the piston to withstand higher mean pressures by supercharging and also to run at higher speeds. The two methods of supercharging considered were (1) to compress to the supercharging pressures the whole of the air required by the engine by means of a blower or pump, the air passing through the induction valve, or (2) to allow the engine to draw air from the atmosphere through the induction valve in the ordinary way and to add at or about the commencement of compression the additional air for supercharging through ports uncovered by the piston or through an additional valve in or near the cylinder head. The alternatives were fully considered, but as the principal object at that time was to test the aluminium alloy piston it was decided to adopt (1) as it did not involve any structural alterations to the engine. It was consequently arranged to compress to the supercharging pressure the whole of the air required by the engine by means of a standard Roots blower, driven by belt from an electric motor. The blower delivered air under pressure to a reservoir, which was fitted with a combined relief and pressure regulating valve, so that the supercharging air could be adjusted to any predetermined pressure within the capacity of the blower. A three-way cock was fitted in the induction pipe so that the engine could take its supply of air either from the atmosphere or from the reservoir. This arrangement gave no trouble, but it was found that the temperature of the air delivered at 3 lb. or 4 lb. pressure after a time rose appreciably and a water-jacket was therefore fitted to the blower.

Tests were then carried out with and without supercharging at various speeds up to 500 r.p.m. using the maximum quantity of fuel oil delivered by the fuel pump. A six-hole sprayer was necessary at the higher speeds and the pressure in the solid injection system was maintained, as nearly as possible, at 4,000 lb. per square inch by adjusting the fuel valve roller clearance—thus varying both the lift and period of opening of the fuel valve. Further, the compression pressure was 380 lb. per square inch and the average initial or maximum pressure was kept at about 630 lb. per square inch by adjusting the timing gear as necessary for each test. The same brand of fuel oil was used throughout, viz., heavy shale oil of specific gravity 0·86 at 60 deg. F. The quantity and rise in temperature of the cooling water to the jacket, cylinder cover and exhaust valve were measured.

During the tests the blower was run at its lowest speed but the amount of air delivered was in excess of that required at all engine speeds. A calculation had to be made, therefore, based on the curves of output and power furnished by the makers of the blower, in order to obtain the power required to supply the air actually used in the engine. The blower was not very efficient and the calculated power required to supply the supercharging air were known to be in excess of those which would be necessary in practice. The results obtained during the 500 r.p.m. series of tests which were run with supercharging pressures corresponding to 0 in., 2 in., 4 in., 6 in. and 8 in. of mercury (as measured by a mercury gauge in communication with the reservoir) are shown graphically in Fig. 1. The fuel consumption per brake horse-power hour inclusive of the blower are estimated. Each trial was of 1½ hours' duration.

Although the powers developed during the tests were limited by the capacity of the fuel pump, the results obtained could not be regarded as satisfactory. The exhaust was not clear during any test and it was evident that it was necessary either to make some alteration to the fuel sprayer or to adopt a different system of fuel injection. It was therefore decided that no good purpose would be served by continuing these tests and it was consequently arranged to experiment with the fuel-injection system and to defer the supercharging tests until a later date.

Better results, both as regards power and fuel consumption, would have been obtained by running these tests at higher initial pressures, but it was desirable, at least for the present, to limit the maximum pressure to that usually worked to on service. The results could also have been improved by using a higher fuel pressure

* Paper read before the Institution of Naval Architects, July 8, 1920.

in the solid injection system but, again, it was considered advisable at that stage, and with the fittings then in use, to limit the pressure to 4,000 lb. per square inch. During the later tests diagrams were taken from the fuel system with the object of ascertaining the variation of pressure during the cycle. For this purpose an ordinary hydraulic indicator was used, but as the fuel oil was found to leak past the piston a U-pipe connection was made to the indicator and filled with heavy oil—so that the heavy oil was in contact with the piston. This overcame the difficulty and it is considered that reliable records of the variation in pressure were obtained. It was found that with a gauge pressure of 4,000 lb. per square inch in the fuel system, with the engine running at 420 r.p.m., the maximum pressure was 4,560 lb. and the minimum pressure 3,400 lb. per square inch.

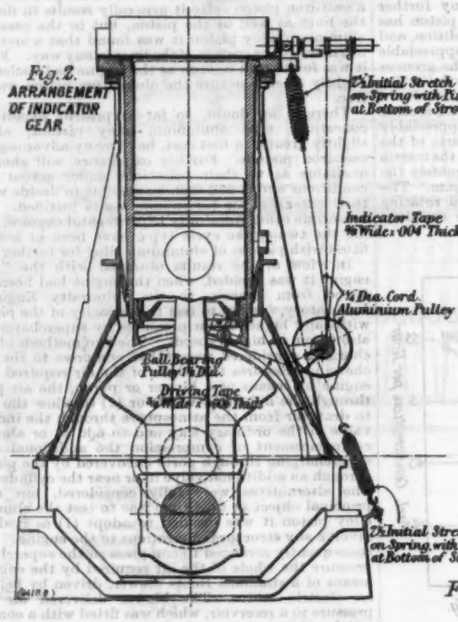


Fig. 2.
ARRANGEMENT OF INDICATOR GEAR
Initial Stretch on Spring with Piston at Bottom of Stroke
Indicator Tape
Dia. Cord
Aluminium Pulley
Ball Bearing Pulley
Driving Tape
Initial Stretch on Spring with Piston at Bottom of Stroke

The exhaust pipe outlet to the atmosphere is some considerable distance from the engine and for convenience it has been arranged to spray water into the first of the two silencers fitted and to note the colour of the discharge from the silencer drain by passing it over a plate of glass painted white on its inner side. It has been found that this method is very sensitive and can always be relied upon to give a true indication of the colour of the exhaust. This method has also been used successfully for other experimental engines.

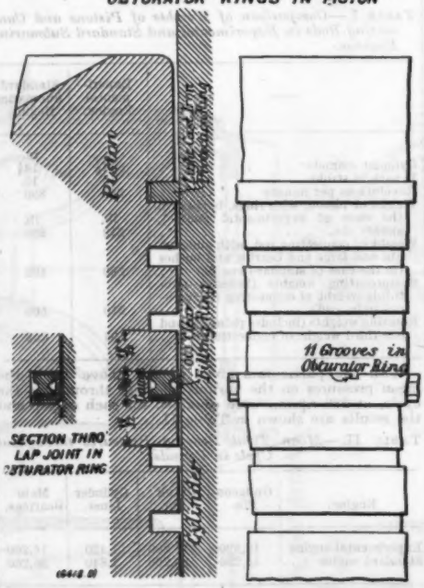
The indicator rig originally fitted to this engine was considered to be unsatisfactory and a new gear was fitted, an arrangement of which is shown in Fig. 2. It will be seen that a steel tape, 0·006 in. in thickness, has one end connected to the piston and the other end connected to the rim of an aluminium wheel, which is mounted on a small shaft carried in a bracket attached to the engine framing. This tape passes over a ball-bearing pulley 1¼ in. in diameter. The shaft carrying the aluminium wheel also carries the pulleys to which the tension springs are connected and the pulley from which the indicator tape is taken. By this means a true copy of the movement of the piston can be obtained. Some difficulties were experienced in connection with the tension springs and the tape fastenings but by running the whole of the gear in the open by an electric motor, so that all parts were under observation, these difficulties were readily overcome. Various minor alterations were made later, but the principle of the gear has remained the same. A photograph of the gear attached to the "Unit" engine is shown in Fig. 3. Since that time a large number of strands of rubber have been successfully used in place of the tension springs.

It may be interesting to mention, in connection with the "Unit" engine, that an obturator ring has been fitted to the piston since August, 1918, and has given fairly satisfactory results. The use of the obturator ring for Diesel engines was brought to notice by Messrs. The Engineering and Arc Lamps, Limited, of St. Albans, as a number of experiments had already been carried out in an engine at the St. Albans Electric Power Station, and very promising results obtained. The top of the cylinder liner of the power station engine was worn to the extent of nearly ¼ in. on the diameter and the life of the phosphor bronze obturator ring under these severe conditions was about 300 hours. The general condition of the liner, however, was such that the ordinary type of cast-iron ring could not be used and the fitting of the obturator ring, although its life was comparatively short, certainly enabled the engine to be run.

In the St. Albans engine the first three cast-iron piston rings were "pegged in" for the purpose of filling the grooves, an obturator ring of L-section, and about 1·5 mm. in thickness, was fitted in the fourth groove, and the three remaining worn rings, below the obturator ring, were retained unaltered. An appreciable clearance was provided between the edge of the obturator ring and the groove in which it was fitted. The question of the gas pressure behind the obturator ring during the cycle was discussed with the firms representatives and it was suggested to them that it would perhaps be an advantage to fit a cast-iron ring in the top groove of the piston in order to protect the obturator ring from the hot gases. Later, when it was decided to fit an obturator ring to the "Unit" engine for experiment, provision was made for a cast-iron protection ring designed to give a radial pressure of about 1 lb. per square inch. Further, the clearance between the edge of the obturator ring and its groove was reduced to 0·002 in.—as by this means it was considered that the pressure behind the ring would, by wire-drawing, be reduced to a minimum.

FIG. 3.

Fig. 4. UNIT ENGINE. ARRANGEMENT OF OBTURATOR RINGS IN PISTON



The arrangement of the L-sectioned obturator ring in the "Unit" piston is shown in Fig. 4. The material used is phosphor bronze and the thickness of the ring is 0·05 in. A lap joint, riveted and silver soldered to one end of the ring, is provided to ensure gas tightness past the gap. A filling ring is fitted, made in halves spigoted together—its width being such that it just allows freedom of movement of the obturator ring.

When the obturator ring was fitted to the "Unit" engine the compression ratio was increased, as it was uncertain whether the ring would be gastight when starting up. Later, however, the compression was reduced again to 380 lb. per square inch at 380 r.p.m. When the engine was first run with the obturator ring, especially for about 15 minutes after starting, an appreciable quantity of gas passed the piston into the crank-case—which would be an objectionable feature so far as its use for submarine engines is concerned—so the ring was removed and eased slightly to give it more freedom. It was clear that only portions of the ring were in contact with the liner and its surface was therefore smoothed up as necessary and 11 slots, 1/32nd of an inch deep and 1/16th of an inch wide, were fitted, as shown in Fig. 4. At the same time the clearance between the edge of the ring and the piston groove was increased from 0·002 in. to 0·003 in. These slight modifications resulted in a distinct improvement and the ring worked satisfactorily with mean indicated pressures up to 140 lb. per square inch. No leakage was apparent although the maximum compression pressure was very slightly less than that previously obtained with the full number of cast-iron rings with the same compression ratio in use. There was a very decided knock in the piston at the end of the compression stroke and after running for a total of about 30 hours it was decided to examine the piston and obturator ring. The obturator ring was found to be quite free and bearing generally and there was no measurable wear. The ring was therefore replaced and, in view of the previous knocking of the piston, two additional light cast-iron rings were fitted below the obturator ring. These additional rings, which were intended to act as "buffer" rings, practically cured the knocking, but they must add slightly to the piston friction of the engine. It is probable that this knocking could have been avoided by reducing the piston clearance, but nothing could, of course, be done with the existing piston; neither was it desirable in view of running the engine at comparatively high mean pressures.

After running for about 150 hours at various powers the obturator ring was again measured and the wear appeared to be about 0·001 in., whilst the maximum wear in the groove of the piston when gauged was found to be 0·008 in. So far the obturator ring is promising, but it has been tested under very favourable conditions, and further experience is necessary before any recommendations could be made in regard to its general use in service engines. The original ring is still fitted in the engine, but there has been no opportunity to ascertain the actual reduction in piston friction resulting from its use. There is no doubt, however, that the engine is more free than formerly and its mechanical efficiency has been slightly increased. It is not known whether any experiments have been made to ascertain whether obturator rings would work satisfactorily when running over ports, such as those fitted in two-stroke cycle engines, but it is probable that this will be tried at the laboratory at a later date.

Very good results have been obtained with the "Unit" engine both with the solid and with the air injection systems. Instructions were received to carry out experiments with the object of reducing the tendency of the standard engines to smoke when using solid injection. A large number of tests were made, which cannot be referred to in detail here, and eventually smokeless combustion was obtained with the "Unit" engine at all powers from 100 brake horse-power to 25 brake horse-power, and the consumption of fuel oil at 100 brake horse-power and 380 r.p.m. was just under 0·4 lb. per brake horse-power hour. Having in view the fact that the tests were carried out with a single-cylinder engine, fitted with a camshaft driving mechanism designed for a multi-cylinder engine, this figure for consumption is remarkably good. The fuel used was shale oil having a specific gravity of 0·86 at 60 deg. F. During all these tests the fuel oil was very carefully measured, and it may be mentioned that during a 6 hours' continuous test the variation in the consumption, recorded half hourly, was under 1 per cent. The "Unit" engine is coupled to a standard Heenan and Froude dynamometer for absorbing the power.

Tests were made with the above engine when using air injection and the fuel consumption at 100 brake horse-power, after making the necessary allowance for the power required to drive the air compressor, was practically the same as the fuel consumption when using solid injection.

Early in 1918, several British firms were asked to produce designs of single-cylinder experimental engines of from 300 brake horse-power to 400 brake horse-power, and one of these engines is now approaching completion. At about the same time a preliminary design for an experimental four-stroke single-cylinder engine of about 300 brake horse-power was prepared by the Admiralty Engineering Laboratory and instructions were received to proceed with the working drawings on May 1, 1918. Photographs of the engine, which was constructed at Chatham, are shown in Figs. 5 and 6, Plate XVI. Owing to space requirements it was eventually decided to design a square engine, 20 in. diameter by 20 in. stroke, developing its full power at 390 r.p.m. The piston speed aimed at was, therefore, 1,300 ft. per minute—which was an advance on previous practice. Although all the drawings were completed before any information was available as to the German designs it is interesting to note that the principal dimensions of the laboratory engine correspond closely with the dimensions of the German engines—the cylinder diameter of the latter being 20·8 in., stroke 20·8 in., and developing approximately 300 brake horse-power at 380 r.p.m.

The first point considered during the preliminary design stage, after fixing the cylinder diameter, &c., was the type of framing to be adopted. After full consideration of the various types it was decided, having in view stiffness of structure as well as weight, to adopt the steel column principle—the casting being of box form as shown in Figs. 5 and 6. For a multi-cylinder engine this framing should prove both rigid and comparatively light. Although it was intended that the framing for a multi-cylinder engine should be of cast steel it was decided, in order to get quick delivery and to keep down the cost, to make the framing of the single cylinder of cast-iron—the scantlings being slightly increased over those necessary with steel. It may be mentioned that, with the exception of the moving parts, cylinder cover, fuel valve and a few minor fittings, parts which were intended to be made of almuinium or cast steel in a complete engine were in this instance made of cast-iron.

A water-cooled cast-steel sandwich plate, carrying the liner, is secured to the top of the column and the cast-steel cylinder head is in turn fitted to the sandwich plate—the studs for securing the head passing through the sandwich plate to the column. The liner now in use is made of close-grained cast-iron, but liners of special steel will be fitted for experiment later. At the lower end of the liner the water joint with the thin sheet steel water jacket is made by rubber rings in the usual way. The upper part of the water jacket is housed in the sandwich plate in such a manner that the pitch of the cover studs is reduced to a minimum. The bedplate is of cast-iron arranged for convenience to embody the lubricating oil pump. The lubricating oil pump, driven by an eccentric on an extension of the crankshaft and housed within the crank chamber, is of the Brotherhood valveless type.

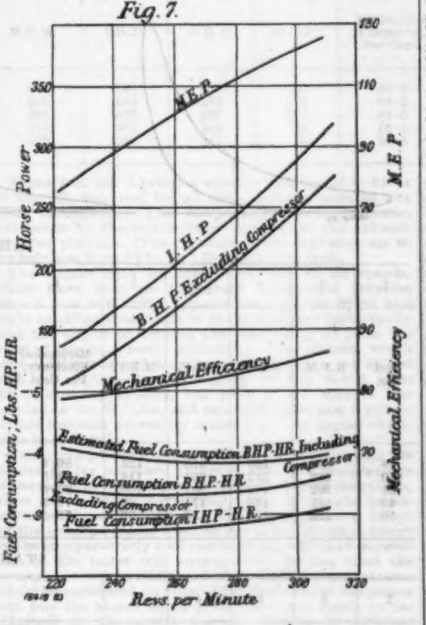
The crankshaft is of ordinary 30-ton to 35-ton steel, and is fitted with cast-steel balance weights, lead filled. The connecting rod is of I-section, of 30 tons to 35 tons steel, with the corners of the palm end cut away, and to suit the piston-cooling gear the length between centres was made 4·9 cranks. The large-end bearing is of cast steel, filled with white metal. The hollow gudgeon pin, of Ubas steel, is shrunk into the connecting rod. The aluminium alloy piston closely followed the design adopted for the "Unit" engine previously described. In view of the results obtained with the "unit" piston it was thought that the 20-in. piston would probably run satisfactorily without any special means of cooling. As there was, however, a doubt about this it was decided to arrange for oil cooling, and the system adopted followed the lines of that fitted by Messrs. Sulzer. A separate motor-driven pump and cooler are provided for the piston-cooling oil. The recess in the head of the piston is hemispherical. There were two reasons for this, viz., that the hemispherical recess resulted in a combustion chamber of good form which would probably facilitate combustion, and also that by adopting this shape in the design of an experimental engine it enabled pistons having heads of other shapes to be fitted for experiment at a later date, if considered necessary, without any structural alterations. The adoption of this shape of piston head adds several inches to the overall height of the engine, but it is considered that it is justified—especially in the case of an experimental engine.

The cast-steel cylinder cover, or head, was made as simple and as light as possible, consistent with stiffness, and care was taken to avoid, where possible, all straight ribbing. Air and exhaust passages are not embodied in the cover. The fuel valve housing, which is amply cooled, connects the top and bottom flanges of the cover and completely surrounds the fuel valve casing. The housings for the air and exhaust valve boxes, which form curved ribs between the top and bottom flanges of the cover, do not completely surround the valve boxes so that the latter are directly in contact with the cooling water. Four large cleaning doors are provided in the sides of the cover. By this design a comparatively simple casting is obtained and, although a considerably reduced depth of cover results from the air and exhaust valve passages not being embodied in the casting, so far as can be seen the cover is stiff enough for all practical purposes—in fact, it may be definitely stated that even when working at high speeds and high mean pressures it is at least as stiff as the cast-steel covers fitted to the standard submarine engines and which have given practically no trouble on service. The water service is taken from the town's main. Cooling water enters the jacket at two points and passes into the cover and the exhaust valve box. The sandwich plate is separately cooled.

It was considered from the point of view of quiet running that skew gears were preferable to spur or bevel drives. Skew gears were therefore adopted, and as it was desired to arrange for an enclosed cam-case, and at the same time to be in a position to remove the cylinder cover without dismantling the valve-actuating gear, push rods and short levers were used as shown in Figs. 5 and 6. It may be mentioned that this gear is very quiet in operation. The air and exhaust valve boxes, which in the experimental engine are of cast-iron, are in two parts—the lower parts having respectively the inlet and exhaust ports cast in them and the upper parts or spring boxes carrying the fulcrum brackets. The air and exhaust valve boxes are secured to the cylinder cover by three studs—copper rings being used for making the joints. Since this gear was designed a slight rearrangement has been made which results in reducing the head room required by about 6 in. The exhaust valve and box are water cooled. The air and exhaust valves are of nickel steel and the cams of steel, hardened and ground.

In high-speed engines it is considered advisable that provision should be made for readily adjusting the timing of the fuel valves—as is adopted in the Vicker's standard engines. In the case of the experimental engine, in order that the timing of the fuel valve can be varied slightly, the fuel cam is mounted on a slideable boss. By the use of helical splines the position of the fuel cam in relation to the camshaft can be altered within the limits of movement of the slideable boss by means of the small hand wheel shown in Fig. 5—connected to the slideable boss

Fig. 7.



by a system of levers and rods. The large wheel is the manœuvring wheel. It was the original intention to fit a special fuel valve to the experimental engine, but, owing to delay in connection with other experiments, it was decided to utilise for the preliminary tests a fuel valve which did not differ in any marked degree from the ordinary air-injection type.

The fuel pump is of the ordinary Diesel type, but it is designed to deal with pressures up to 6,000 lb. per square inch so that "solid" injection can be employed at a later date if desired. The quantity of fuel pumped is regulated by means of the fuel pump suction valve in the usual manner, through suitable levers connected to the manœuvring gear. The operation of starting, &c., is very similar to that adopted in many other engines and requires no special description. There is a mechanically-operated starting control valve and an automatic starting valve on the cylinder head—the water-cooled box containing the automatic valve being also utilised for accommodating the relief valve and indicator connection, so that only one hole in the cover is necessary for these fittings. The engine is not reversible. No difficulties are, however, anticipated in connection with the fitting of the reversing mechanism to a multi-cylinder engine—in fact, the drawings have already been completed. The reversing mechanism is one of the simple problems in Diesel design, and there is no doubt that this part of a marine engine has given the least trouble, except in one or two cases where the gear was unsuitable for sea-going conditions. A Ruston standard governor is fitted on the vertical shaft and arranged to cut off the fuel supply when the engine reaches a speed of about 420 r.p.m.

The fulcrums for the compound fuel valve actuating levers are carried by a separate casting secured to the cylinder cover—so that there is no fulcrum bracket attached to the fuel valve casing. When the fuel supply is altered the lift of the fuel valve is also modified slightly. The lift of the fuel valve can also be adjusted independently by means of a separate hand-control gear carried on one of the camshaft brackets—but this is intended only for experimental purposes and need not be embodied in a multi-cylinder engine. A cast-steel flywheel, giving a cyclic irregularity of about 1/35, is fitted so that a high peripheral speed can be safely employed. Holes are provided in the rim of the flywheel for taking a turning bar.

Forced lubrication is employed throughout. The cylinder liner and exhaust valve spindle are lubricated by a mechanical lubricator. The indicator gear is of similar design to that already described, and, following the practice adopted in the case of other engines, separate gears are fitted for taking combustion and fuel valve lift diagrams. It was originally intended that the air compressor should be driven by the engine but it was eventually decided, in view of future work, to drive it independently. The power developed by the engine is absorbed by a Heenan and Froude dynamometer. The fuel consumption is measured by weighing the amount of fuel consumed by the engine, a weighing machine and a fuel tank having the usual narrow neck, in which a point gauge is fitted, being used for the purpose. Other points in connection with this engine require no special reference as they generally follow the ordinary accepted practice. It might be mentioned, however, that in a completed engine aluminium would be made use of as far as possible, although it would not be proposed at this stage to utilise any special steels.

The engine was first started on fuel on October 28 of last year, and short runs were made, using Texas fuel oil, at 250 r.p.m., the maximum compression pressure with a compression ratio of 13·15 being 475 lb. per square inch. During these runs no oil was used for cooling the piston. When the piston was examined it was found to be in excellent condition, and it showed an even bed on the liner and it was therefore replaced. The speed and power of the engine were then gradually increased to 350 r.p.m. and 200 brake horse-power. There were no mechanical difficulties at this speed but it was found that the resistance in the fuel valve to the passage of air and fuel was too great and a number of pulveriser washers were consequently removed. This modification enabled 168 brake horse-power to be developed at 300 r.p.m., but the quantity of pulverising air used was still insufficient—in fact, the fuel valve was working as a very inefficient solid injection valve—and the fuel consumption was 0·6 lb. per brake horse-power hour.

The fuel valve of this engine, as in the case of the air-injection valve fitted to the engine previously described, was provided with a distributor containing a large number of small holes so that the air sprays corresponding to each hole could be directed into the combustion chamber in any predetermined direction. This is essential for engines running at high speeds and with comparatively high mean pressures, and it is interesting to note that the fuel valves of the German submarine engines are fitted with multiple hole distributors and other firms have also recently adopted this as standard practice.

In view of the resistance in the fuel valve of the experimental engine it was decided to remove all the pulveriser washers and to replace the distributor by one having a small number of larger holes, as it was desired to limit the pressure of the blast air to 1,000 lb. per square inch when the engine was developing its full output. This alteration resulted in 168 brake horse-power being developed at 300 r.p.m. with a fuel consumption of 0·35 lb. per brake horse-power hour—a marked improvement on the result previously obtained. This figure for consumption does not include the power required to drive the air compressor.

At this stage the revolutions of the engine had to be limited to 300 r.p.m., and the running generally was considerably restricted owing to complaints in regard to vibration. On a few occasions, however, before the speed was limited the engine had been run at its rated speed with no signs of trouble. It might be mentioned that whilst the balance weights attached to the cranks reduce the magnitude of the vertical unbalanced forces, they introduce a horizontal couple in the athwartship plane, and as the centre line of the engine is, on account of the lay-out of the laboratory, unavoidably 11 ft. from the ground level, the rocking of the engine at high speeds was fairly marked. As 300 r.p.m. could not be exceeded, although a few tests were actually run at about 320 r.p.m. after this time, it was decided to carry out tests at about this speed and at lower speeds with the object of improving the fuel consumption. Typical results obtained are shown in Table III.

The power required to supply the blast air is not accounted for in columns 3, 6 and 10. The compressor used is of the Reavell type, driven by belt from an electric motor. Column 8 gives the horse-powers absorbed by the compressor after making the necessary deductions from the effective horse-power, based on a combined motor and belt efficiency of 85 per cent. The speed of the electric motor can be varied slightly, but beyond this the air delivered in excess of requirements is blown off between the first and second stages. Owing to the design of the compressor it is not possible, as is done in the case of the other experimental engines, accurately to measure the quantity of blast air actually used by the engine when it is running. By noting, however, the time required to pump up the bottles over small ranges of pressure when the compressor is running at the same speeds, &c., as during the tests an approximation can be obtained of the air used, and therefore of the power required to supply this air. It was found that in all cases the powers given in eglumn 8, Table III, exceeded those calculated from the figures obtained for the quantity of air pumped. It was considered desirable, however, to take the higher figures, i.e., those shown in column 8, for estimating the fuel consumption per brake horse-power, including the compressor—shown in column 11, Table III, but it may be pointed out that in the author's opinion these results are slightly higher than would be obtained if the compressor were driven by the engine and definite fuel consumptions obtained for the

ne brake horse-power developed. These remarks apply also to the figures given in Table IV.

As already mentioned, the figures given are typical of the results obtained for many tests with distributors having various numbers, sizes and angles of holes, and for convenience they are shown graphically in Fig. 7. The fuel used during all these tests was Texas fuel oil, having a specific gravity of 0·92 at 60 deg. F. The exhaust during these tests was smokeless, but it was found when running at higher mean pressures, just above 130 lb. per square inch, the exhaust became slightly shaded.

A number of tests, many of from 2 hours' to 6 hours' duration, were also carried out at about 300 r.p.m., with mean indicated pressures of about 150 lb. per square inch, and with various distributors—the object being further to test the piston. The exhaust during these tests was shaded. The particulars given in Table IV are typical of the results obtained. At the end of 100 hours' running at various powers, the engine was opened out for inspection, and the piston, top-end and bottom-end bearings were found to be in excellent condition. The engine runs smoothly and well at the higher speeds. At the lower powers a very slight piston knock is sometimes noticeable, which would indicate that the piston clearance is slightly greater than necessary at these speeds. There is no knock, however, at the higher powers.

The quantity of piston cooling oil circulated through the system when running at 314 brake horse-power at 314 r.p.m. was only 210 gallons per hour—the rise in temperature of the cooling oil being 64 deg. F. If we assume, therefore, that the calorific value of the oil is 18,400 British thermal units (lower heating value), the quantity of heat carried away by the cooling oil is about 2·3 per cent. of the heat supplied. At lower speeds and also at lower mean pressures at the same speed, the percentage of heat passing to the cooling oil is slightly higher. It would probably be advisable to pass a larger quantity of oil through the piston and reduce the rise in temperature, but so far no alteration has been made to the engine in this direction.

Further tests are, of course, proceeding, and later it will be possible to continue the tests at the higher speeds. So far no mechanical difficulties have been encountered, and it is not anticipated that any trouble will arise which will prevent the engine developing at least the rated net brake horse-power, i.e., the brake horse-power arrived at after making full allowance for the power required to drive the air compressor.

By running an engine at high mean pressures a greater power can be developed in a given space and the weight per brake horse-power is reduced. It is well-known that many makers of marine oil engines are of the opinion that it is unwise to work with mean indicated pressures much in excess of 100 lb. per square inch—in fact, the present tendency seems to be to reduce this figure. This is no doubt the result of past experience, and may be desirable in the case of merchant ship engines. The requirements of a naval engine, however, differ considerably from those of a merchant engine, and it is felt that if progress is to be made with naval engines the use of higher mean pressures should be seriously considered. In all the experiments which have been carried out at the Admiralty Engineering Laboratory, therefore, the adoption of high mean pressures has always been kept in mind. It was for this reason that the experimental engine just referred to was designed with a rated mean indicated pressure of about 120 lb. per square inch.

No difficulty has been experienced at the laboratory in running high-speed Diesel engines working on the four-stroke or two-stroke opposed piston cycles, at 130 lb. M.E.P., with a smokeless exhaust when using Texas fuel oil, but in each case air injection has been necessary, as smokeless combustion has not so far been obtained with the solid injection system at mean pressures much in excess of 100 lb. per square inch.

For the pressures above 130 lb. per square inch it is probable that supercharging will be adopted, and the problem of working at these high mean pressures with a smokeless exhaust is primarily one of successful fuel injection—in fact, the fuel injection valve is the heart of the high-speed engine.

At present it is usual to work with a compression ratio as low as possible and to obtain economy by introducing the fuel oil before the top dead centre. This results in a rise of pressure at (approximately) the dead centre, which in the case of the Laboratory experiments has so far been limited to 630 lb. per square inch. The introduction of supercharging air would result in a high compression pressure with the same compression ratio, and consequently, if it were desired to work with the same limiting maximum pressure after injection, the fuel would have to be injected later. This, apart from other considerations, would result in a slightly higher fuel consumption per horse-power.

The greater charge-weight of air in the working cylinder when supercharged should enable more fuel to be satisfactorily burned, resulting in a higher mean pressure. The temperatures throughout the cycle when working at high mean pressures with supercharging in use would not necessarily be higher than when working with lower mean pressures without supercharging—i.e., temperature difficulties would not be increased as a result of the adoption of supercharging. The supercharging engine would be slightly more complicated, and additional air pumps would be necessary, which would slightly reduce the mechanical efficiency of the engine; but these pumps would have to deal only with comparatively low pressures. It may be taken that if 50 per cent. more power was developed by supercharging, approximately 10 per cent. would be absorbed in supplying the supercharging air, i.e., there would be a net gain in power of 40 per cent.

A low fuel consumption is not the only desideratum for naval engines, and it is considered, therefore, that supercharging experiments are fully justified, and the 300 brake horse-power experimental engine already described will be modified for this purpose at a later date. In this instance air will be drawn through the inlet valve in the ordinary way, and the supercharging air will be introduced through ports in the liner towards the end of the suction stroke of the piston. The air will be supplied by a rotary blower, and arrangements made so that the blower can be cut out when the supercharging air is not required.

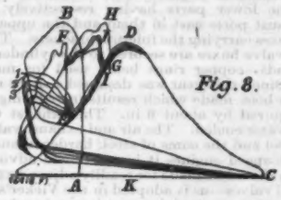


Fig. 8.

Although it is not proposed to give a description of the large German submarine engines, a comparison between the weights of the piston and connecting rod of the German engine and the Laboratory engine already referred to, of approximately the same brake horse-power per cylinder, is given in Table V above.

One of the first starting diagrams taken from the 300 brake horse-power Laboratory engine is shown in Fig. 8. This diagram was taken with an indicator gear 90 deg. out of phase with the ordinary indicator gear. It will be seen from the diagram that when starting air was admitted into the cylinder the piston was in a position corresponding to A, and the rise of pressure is along the line A B. K C D is the compression curve, and subsequent admissions of starting air are shown by the curves 1, 2, &c. The first ignition of oil is shown by the line E F, the second ignition by G H, the third by I J. It will be noticed that as the speed of the engine increases the maximum compression pressure increases slightly, and also, omitting the first ignition, the ignition occurs later—the timing gear being kept in the same retarded position throughout. Figs. 9, 10 and 11 are ordinary diagrams representative of those taken from the engine.

It is considered unnecessary to refer to the past history of high-speed Diesel engines, as we are principally concerned with the future. It is hoped, however, that in the future technical opinions in regard to the process of development will be more readily accepted than they have been in the past, for there is no doubt that in many instances progress has been arrested by the lack of success which has frequently followed the action taken as the result of the influence of the enthusiastic amateur. If progress is to be made, development must take place step by step—for it is the only sure way.

The high-speed high-duty oil engine is a much more difficult problem than the low-speed low-duty type, and as the Admiralty is the principal user of the former it is reasonable and essential, in the author's opinion, that an Admiralty Laboratory should carry out at least a

Fig. 9. CYL. DIA. 20 IN, STROKE 20 IN, R.P.M. 300, M.E.P. 142·5 I.H.P. 839. B.H.P. 300, MECH. EFF. 88·5, FUEL, TEXAS; COMP. PRESS. 480.

Fig. 10. CYL. DIA. 20 IN, STROKE 20 IN, R.P.M. 262, M.E.P. 99·6, I.H.P. 207, B.H.P. 173, MECH. EFF. 83·6 FUEL, TEXAS; COMP. PRESS. 475.

Fig. 11. CYL. DIA. 20 IN, STROKE 20 IN, R.P.M. 222, M.E.P. 76·6, I.H.P. 135, B.H.P. 106, MECH. EFF. 78·5. FUEL, TEXAS; COMP. PRESS. 475.

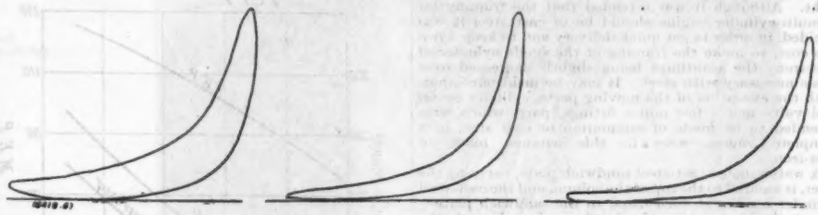


TABLE III.

1	2	3	4	5	6	7	8	9	10	11
								Fuel Consumption. Lbs. per H.P.-Hour.		
Test No.	R.P.M.	B.H.P.	I.H.P.	M.E.P.	Mechanical Efficiency, Per Cent.	Blast Pressure, Lb. per Sq. In.	H.P. of Compressor.	I.H.P.	B.H.P. excluding Compressor.	B.H.P. including Compressor (estimated).
28	309	268	310	126	86·4	960	27·3	0·31	0·36	0·4
30	282	212	254	114	83·5	960	27·3	0·28	0·34	0·39
31	262	173	207	100	83·6	880	23·2	0·28	0·33	0·38
49	245	138	174	90	79·4	750	18·2	0·28	0·35	0·4
50	222	106	135	76	78·5	700	17·3	0·27	0·34	0·41

TABLE IV.

1	2	3	4	5	6	7	8	9	10	11
								Fuel Consumption. Lbs. per H.P.-Hour.		
Test No.	R.P.M.	B.H.P.	I.H.P.	M.E.P.	Mechanical Efficiency, Per Cent.	Blast Pressure, Lbs. per Sq. In.	H.P. of Compressor.	I.H.P.	B.H.P. excluding Compressor.	B.H.P. including Compressor (estimated).
24	314	314	373	150	84·1	1,000	24·7	0·39	0·46	0·5
25	313	313	358	144	87·4	1,000	26·7	0·37	0·42	0·46
57	288	288	344	150	84·4	900	23·3	0·33	0·39	0·43
63	284	284	322	143	88·2	1,000	28·2	0·32	0·36	0·4
65	283	283	334	149	84·7	1,000	27·8	0·33	0·39	0·43

TABLE V.—COMPARISON BETWEEN GERMAN AND ADMIRALTY ENGINEERING LABORATORY ENGINES.

Engine.	Cylinder. Diameter.	Stroke.	R.P.M.	Connecting Rod, including Bottom and Top End Brasses.		Piston, complete with Pipes and Guards.	
				Total Weight.	Weight per Square Inch of Piston.	Total Weight.	Weight per Square Inch of Piston.
	in.	in.		lb.	lb.	lb.	lb.
German	20·8	20·8	380	938	2·76	945	2·78
Admiralty Engineering Laboratory	20·0	20·0	390	820	2·61	503	1·6

portion of the experimental work involved in its development. There is no reason for the Laboratory experiments in any way to stifle the initiative of firms or individuals in the development of the high-speed engine, but it is hoped, and expected, that the Laboratory will be the means of assisting and co-ordinating the work. Members of the Institution will doubtless agree that the naval engine should be the best available, and consequently it should embody details which are recognised from time to time as being the best on the market. This can only be brought about by the Admiralty, and in this connection at least the Admiralty Engineering Laboratory should prove its value.

Comparisons have frequently been made between Diesel engines of various types in regard to power and space occupied, but in many cases such comparisons have either been based on assumptions which could not be wholly accepted or certain assumptions have been taken no doubt with the object of emphasizing the advantages of a particular engine. A short time ago the author had occasion to look into this question with the object of ascertaining the approximate brake horse-power which could be developed by high-duty Diesel engines of the four-stroke single-acting, two-stroke single-acting and two-stroke double-acting types, designed for the same overall length and height. The engines considered were based on Laboratory designs. It is not possible in this paper to give in detail the whole of the assumptions made, but the principal points assumed were: (1) Air injection in all cases; (2) the compressor and scavenge pumps driven from the main engines; (3) separate guides in the case of the two-stroke engines and trunk pistons only in the case of the four-stroke engines. Taking the power developed by the eight-cylinder four-stroke engine as the unit, the comparative figures obtained are shown in Table VI.

TABLE VI.

Type of Engine.	Number of Cylinders.	Comparative Figure for B.H.P. (eight-cylinder four-stroke Engine taken as Unity).
Four-stroke, single-acting ..	8	1·00
Four-stroke, single-acting ..	6	1·22
Two-stroke, single-acting ..	6	1·44
Two-stroke, single-acting ..	8	1·38
Two-stroke, double-acting ..	6	1·9

With the assumptions taken it will be seen that it is advantageous to keep down the number of cylinders in an engine; also, the increase of power resulting from the adoption of the two-stroke single-acting engine is not very marked. There is a distinct advantage in favour of the two-stroke double-acting engine, but it would be more complicated, and its use could only be justified for higher powers than those at present contemplated.

Although the comparative figures arrived at are correct for the assumptions taken, other points, in addition to space occupied, have to be considered when deciding on the type of engine to be used for powers larger than those at present in use or under construction. The advantages and disadvantages of the various types are well known and need not be discussed in this instance. For powers of the order of 2,000 brake horse-power per engine for high-speed naval work there would be no great difference in the widths of the three types of engines, but as the power increased it is probable that the width of the four-stroke engine would be slightly greater than the widths of the two-stroke engines—at least so far as the six-cylinder engine is concerned. This would necessitate a wider engine room in order to accommodate pistons and covers when dismantling.

It has been assumed in these comparisons that the four-stroke engines are not fitted with separate crossheads, as in the case of the two-stroke engines. If separate crossheads were fitted, it would be necessary to reduce the stroke of the engine for a given head-room, so that either the piston speed would have to be reduced, or if the piston speed were maintained the inertia forces would be increased. This, in addition to the size of the cylinder, &c., would probably limit the use of four-cycle engines for comparatively high powers.

Other assumptions in regard to the method of driving the scavenge pumps, number of cylinders per engine, &c., could be taken in order to arrive at comparative figures for brake horse-powers solely from the point of view of space occupied, but it is considered that the cases worked out give a good idea of what may be generally expected. It is clear from the results given that, compared with the four-stroke engine, the increase in power obtained by the adoption of the two-stroke single-acting or two-stroke double-acting engine is not so great as is frequently stated.

Although, from the point of view of actual performance under sea-going conditions, the four-stroke engine has proved more reliable than the two-stroke engine for submarine propulsion, the possibilities of the latter cannot be overlooked. The four-stroke engine was the first in the field and has received more attention, but the two-stroke engine is the natural line of development, and it may prove of considerable value should greater powers be required in the future than those at present contemplated.

A low fuel consumption is, of course, desirable, but other factors, *e.g.*, weight and space, are also of great importance where naval engines are concerned. If, therefore, the two-stroke engine is developed so that there are no doubts as to its reliability, it is considered that it will prove a serious competitor to the four-stroke engine, even for moderate powers, for it can be made a more simple engine so far as the vital parts are concerned.

In addition to the engines already mentioned, other engines have been experimented with at the Laboratory and interesting and valuable results obtained, but it is not possible within the limits of this paper to make more than a brief reference to them. The following engines and plant are being experimented with or are under construction, in addition to those already mentioned:—

Opposed-Piston Engine.—The opposed-piston type of two stroke engine is represented by a single-cylinder, totally-enclosed engine, which was obtained from Messrs. W. Doxford and Sons, Sunderland. This engine was designed by the firm as an experimental submarine unit, originally for their own use. It follows the firm's usual design, which is generally well known and need not be described here, and has a diameter of 14·55 in. and a combined stroke of 28·3 in. The double-acting scavenge pump and four-stage air compressor are driven from two cranks on an extension of the engine-shaft. This lay-out for a single-cylinder engine reduces its mechanical efficiency slightly, especially having in view the fact that the scavenge pump and compressor were made larger than necessary for ordinary running, for the purpose of supercharging experiments at a later date.

The engine had not been run when it was delivered to the Laboratory. A large number of tests have now been carried out, and after making various modifications, particularly to the two fuel valves, very good results have been obtained. The representative results shown in Table VII may be of interest.

TABLE VII.

R.P.M.	I.H.P.	B.H.P.	M.E.P.	Mechanical Efficiency, Per Cent.	Blast Pressure, Lb. per Sq. In.	Temperature of Exhaust Gases, Deg. F.	Fuel per H.P.-Hour.	
							I.H.P.	B.H.P.
322	500	333	130	66·6	1,325	700	0·32	0·48
305	436	280	126	64·2	1,225	633	0·30	0·47
286	365	230	107	63·0	1,100	575	0·29	0·47
285	308	185	93	60·0	1,000	527	0·29	0·48
240	249	141	87	56·6	900	463	0·28	0·49

Texas fuel oil, having a specific gravity of 0·91 at 60 deg. F, was used for all tests, and the exhaust was clear throughout. The temperature of the exhaust was taken by thermocouple as close up to the exhaust ports as possible. The pressure of the scavenge air in the belt was from 2½ lb. to 3 lb. per square inch.

The engine runs smoothly and well at all speeds. There have been no important mechanical troubles since a new and stiffer top-end bearing was fitted and slight modifications made to the compressor (principally with the object of keeping the lubricating oil from the walls of the compressor cylinders). The pistons, which have steel heads and aluminium alloy skirts, are cooled with oil. Originally the cooling oil was taken from the lubricating system, but after a few runs it was decided to modify this, and separate tanks and a pump, in this instance driven by a belt from the engine shaft, have been fitted.

The upper piston is fitted with thermocouples, and the results so far obtained indicate that the temperature of the metal at a point ½ in. from the surface of the piston, when the engine is developing about 300 brake horse-power, is about 630 deg. F. The upper piston is swept by the exhaust gases, whereas the lower piston is swept by the comparatively cool scavenge air, and the temperature of the latter will consequently be less than the former. It was anticipated that higher temperatures would be registered, in view of the thickness of the piston top, but the above figure gives the mean result so far obtained at the power stated. Pistons of different material are now in hand and will be fitted at a later date.

Brief reference might be made to the phenomenon of detonation. In the opposed-piston experimental engine detonation was experienced at the higher powers and speeds, and although not harmful, it would, if heavy, be rather distressing in a multi-cylinder engine. It was very desirable, therefore, that every effort should be made to eliminate the tendency to detonate, but so far it has not been possible to do this completely without at the same time increasing the fuel consumption slightly.

This question was investigated and curves of rate of change of pressure, &c., were obtained from combustion diagrams which clearly indicated that detonation was accompanied by an extremely rapid rise in pressure. From an analysis of the diagrams taken with varying degrees of detonation, the engine developing approximately the same brake horse-power and the same speed throughout, it was found that: (1) An increase in the rate of heat supply, *i.e.*, in the rate of combustion of the fuel, resulted in increased detonation; (2) in the case for low detonation diagrams heat was supplied later in the expansion stroke than in the case of high detonation diagrams; (3) the maximum and mean temperatures of the cycle were greater in the low detonation diagrams than in the high detonation diagrams; (4) the thermo-dynamic efficiency was higher in the case of high detonation diagrams than in the case of low detonation diagrams.

From the experiments which were carried out it was clear that detonation was a function of the speed of injection with the particular fuel used (Texas fuel oil), but when working at high mean pressures an increase in the quantity of fuel injected, other conditions remaining the same, tended to decrease detonation, and in this instance the exhaust did not remain colourless.

Compound Internal-Combustion Engine.—The design of this engine, which was the outcome of a proposal and outline sketches submitted by Mr. H. Ricardo to the Internal-Combustion Sub-Committee, was commenced at the Board of Invention and subsequently completed at the Laboratory. It was constructed by Messrs. P. Brotherhood to working drawings supplied by the Laboratory. After a number of tests had been carried out, it was decided that in view of the unavoidable complication of the engine for marine purposes and the pressure of other work to discontinue the experiments for the present. Ordinary town's gas was used for the preliminary tests.

Hot-Bulb Engine.—A 40 brake horse-power single-cylinder Bolinder engine has been obtained, but this will not be erected until the Laboratory is transferred to West Drayton.

30 *Brake Horse-Power Single-Cylinder Four-Stroke Diesel Engine.*—This is being constructed principally for use in connection with the testing of fuel oils. Delivery will be made shortly.

Paraffin Engine.—In view of the number of paraffin engines now in use in the Navy, a four-cylinder engine for about 50 brake horse-power has been obtained and tests have commenced.

Two-Stoke Single-Acting Engine.—A single-cylinder single-acting two-stroke engine of about 400 brake horse-power is being constructed for the Admiralty by Messrs. J. S. White and Co., Cowes. The working drawings were undertaken by the firm, the outline design and drawings of various details being provided by the Laboratory.

Two-Stroke Double-Acting Engine.—Although the head-room available in present submarines precludes the use of the double-acting engine, it was felt that from the point of view of general development it was desirable to consider this type. A preliminary design has therefore been made which may be taken up at a later date. It was understood that previous troubles with double-acting engines were largely due to the difficulty of obtaining satisfactory fuel combustion on the under side of the piston. In the Laboratory design, therefore, special attention has been given to this point, as well as to the design of the covers and liner.

Small Plant.—A number of small pieces of apparatus have been designed by the Laboratory and constructed for experiments in connection with fuel injection; the study of the fuel spray; the ignition temperatures of fuel oils from the engineers' standpoint; the testing of white metal for bearings and material for piston rings, &c.

The fuel injection problem is of the utmost importance in connection with the successful development of the high-speed marine oil engine, and it is hoped that it will be possible at a later date to give some information on this subject.

It has frequently been stated that the Continent has been ahead of this country in regard to the development and manufacture of marine oil engines, largely on account of the use of better materials. Although it is thought that in the past there has been a certain amount of truth in this statement, largely due to continental engineers more thoroughly appreciating the value of the metallurgist and metallurgical work, there were, of course, other factors entering into the question which need not be discussed here. It is true that many difficulties in connection with oil engines may be overcome by improvements in, and, if possible, a simplification of, the design, but when developing high-duty engines and apparatus for naval purposes a full knowledge of the properties of the materials employed is absolutely essential. Consequently, if progress is to be made, the engineer and metallurgist must work together—under the same roof—and it is certain that the metallurgical section of the Laboratory which has recently been set up, under the supervision of Dr. O. F. Hudson, will be of the greatest value in elucidating the various problems which frequently arise. In conclusion, the author wishes to express his thanks to the Admiralty for permission to read this paper; also, to the staff of the Laboratory for their valuable assistance in connection with the experiments.

CORROSION IN COKE OVENS.—At the annual meeting of the Society of Chemical Industry, at Newcastle, on the 13th inst., Mr. W. J. Rees read a paper on "Coke-Oven Corrosion," in which it was shown that the presence of salt in coal is an important factor in the life of the oven. It was estimated, from analyses of the washings and drainage water from slack, that in average practice in South Yorkshire about 50 lb. of sodium chloride and 20 lb. of sodium sulphate are carried into the coke oven with each charge of slack. As the internal walls of the oven do not reach a temperature at which salt glazing is rapid, the salt vapour penetrates the brick until a zone is reached where the temperature is high enough for a rapid interaction between vapour and brick, the whole process resulting in the formation of a spongy mass that may "ball" or be dragged away by the moving coal or coke. The presence of a layer of hematite in that portion of the brick where shearing and disintegration take place is apparently due to the formation and penetration of ferric chloride, and its subsequent oxidation. In regard to the substitution of other types of brick, recent improvements in the process of manufacture have resulted in the production of silica bricks which, as American experience has shown, behave satisfactorily under the conditions of coke-oven practice.

THE HUMAN FACTOR IN INDUSTRY.*

By ALEXANDER RAMSAY, of Lincoln.

THE prosperity of an industrial community is largely governed by the efficiency and energy of its wealth-producing classes. Of these the brain-worker is not the least important. To him we owe the comforts and refinements of modern society; he has been eager to wrest from nature the secrets she carried in her bosom and mould them to the use of man and the progress of humanity. He has devoted himself with enthusiasm and sacrifice to the patient and laboured elucidation of scientific truths which have added much to the knowledge and resources of the world. He made possible the marvellous productive capacity of a machine and labour-saving age. His place in industry, his training, scope and encouragement would afford an interesting and profitable study. But the most perfect piece of mechanism is without value unless guided by labour. The most brilliant product of the mind cannot become material until labour has performed its function. The whole structure of industry is ultimately at the mercy of those who work with their hands. Their attitude towards the problems of production is of supreme importance, and inasmuch as that attitude at the moment gives rise to some anxiety, it is to this phase of the subject that attention will be directed.

The country is still in the aftermath of the war. Over a considerable period it became accustomed to a prodigal expenditure of wealth without particular scrutiny of the value received. Employers and workers alike were dipping into a purse which seemed bottomless; expectations were high; rewards were high; the art of spending was tremendously encouraged. It is obvious, of course, that during this period the nation was disposing not of its revenue but its capital, and that to such a process there must be a definite and speedy end. Moreover, the continued expenditure of capital resources has the effect not only of dissipating wealth but of rendering it impossible to create more. The employers are very rapidly appreciating this truth and taking suitable action; sections of the workers appear to act as if the national wealth were illimitable and bore no relation to that which is produced.

The activities of the workers are divided in two main channels which are rapidly converging—the industrial and political. In the industrial sphere attempts are made to secure better conditions from the individual employer or group of employers, and in the political to obtain general advantage, and to effect ultimately a fundamental change in the organisation of industry by the nationalisation of the means of production and exchange. These ambitions are perfectly understandable and legitimate, and if the workers believe in them they are entirely justified in pursuing them; but there is an unfortunate disposition amongst a section of the leaders of the labour movement to regard the employer as one who stands between them and their reasonable aspirations, and who must accordingly be fought by every weapon at command. No apparent regard is paid to the fact that the institutions he represents are the foundations of the State, and that such merely destructive activities immediately react on the prosperity of the community. There is a tendency to seek the fulfilment of the new ideas, not by the cumulative effect of sound constructive work, but by the destruction of the present system on which, until something better is evolved, the livelihood of the whole nation depends. In other words, these doctrinaires are consciously at war with the present organisation of industry, and their attitude is expressed in a general encouragement of mistrust, impatience, antagonism, and complete indifference to productive efficiency. It would not be true to say that the bulk of the workers are dominated by this idea, but the application of their unreasoned philosophy leads to very much the same thing.

The past six years have witnessed a tremendous development in the status of labour—against which there is nothing to be urged. Wages have largely increased, hours of work have been lessened, and the organisation of the workers has been enormously strengthened. But with this new sense and experience of power, certain irresponsibilities have resulted which are most disastrous. In a certain industry, for example, subsidised by the taxpayers, the wages have increased 300 per cent., and individual output, it is alleged, has fallen at least 50 per cent. Most of the great trade unions of the country have declared against working a system of payment by result in spite of the most complete safeguard for the inefficient, and in spite of the fact that this system is beyond all question the most effective to induce production and in principle the most equitable to all concerned. Over a considerable period there has been a national embargo on the working of overtime. Avoidable overtime is an evil which cannot be defended. Overtime on a key operation is on occasion an essential, which it is sheer folly in these times to refuse. Overtime to pour a casting to provide work for a gang of men, or to release a cargo steamer to catch a tide, are instances which would have been acknowledged, had there been any disposition to examine the question on its merits; and still demand follows demand for further and increased advantages.

These circumstances are not referred to by way of recrimination, but because they indicate an attitude of mind. They indicate that the workers do not believe that the country is now in such a position that only greatly increased production can save it from industrial disaster. They do not realise that their well-being can only be assured, provided they are able to exchange freely the manufactured articles they produce for the commodities which they must obtain from other peoples: and that, too, in competition with other manufacturing communities similarly situated. They do not appreciate the fact that the cost and bulk of our production must determine the cost and bulk of those things we desire to import for our maintenance or comfort, and that to this extent the cost and standard of living would appear to be factors largely governed by themselves. They are holding out both hands to grasp at privilege and do not count the cost.

This, in brief, is the pressing problem with which industrial statesmanship is faced. Many of the industries of the country, if not already there, are rapidly drifting into a position which is economically unsound. If the tendency to take out of industry more than is put into it is further pursued, or if the destructive theory is more extensively accepted by the workers that the debilitation of the present organisation is, in itself, something desirable to achieve, there is before the country a period of grave economic crisis and social danger. Industry cannot be subsidised indefinitely by the taxpayers, or carried on out of capital resources, and unless the nation settles down to work and produces what it seeks to enjoy, it cannot escape the disaster resulting from the defiance of such elementary need. It is desirable that some other means than bitter experience be found of demonstrating that it is useless to evolve theories of distribution if nothing exists to distribute, because in the times we face, disillusionment and distress are evils that will not live alone.

Now the probability is that the situation has not got beyond a point where it can be regulated, provided the mind of industry addresses itself to the problem. A remarkable combination of circumstances, due to the war, and necessitating continuous employment at whatever cost, have given the workers an unbalanced perspective and created illusions which, in the nature of things, cannot be maintained. It is unthinkable that a usually well-balanced community would commit economic suicide if it realised what was taking place. The average British workmen in his individual capacity is pre-eminently a sane and reasonable being, and he will rise to meet a necessity which he understands. The need for educative propaganda therefore is pre-eminent.

It is a first necessity that he should be made to understand that he is getting a "square deal." His spirit of reason can only be approached through his spirit of fair-play. It has been a striking fact that in the seething turmoil of the mining industry, excessive demands have not been justified popularly, on the ground that the miner's conditions of employment were improper, so much as on the ground that he desired a large sharer of the profits which he alleged the employers were making. The cotton industry has recently witnessed a financial manipulation whereby stockholders have realised a capital appreciation of remarkable extent. Is it to be supposed that the spinners will be satisfied until they have shared in the spoils? The plain fact is, that the workers are now strong enough to exact a fair proportion of the profits of production, and it would be wise to make it quite clear that the employer shares in their desire. Let the employers attempt to create an atmosphere of good-will, and reciprocated good-will can at least be possible.

If two parties are inseparably associated, and differences arise which cannot be ignored, peace will be best assured by frank and friendly discussion. In this connection the National Industrial Conference was a splendid conception, and it is a great misfortune that its potentialities have not been more fully developed. But the individual can do a great deal. Those acquainted with the problems of management should, wherever possible, establish personal contact with the worker and keep him in touch with the world factors affecting the particular product on which he is engaged. But one of the main difficulties of laying an effective case before the men lies in the fact that in a large workshop it is only possible for the directional heads to get into personal contact with a very few individuals. These delegates may be perfectly honest, but it is unreasonable to expect them when reporting discussion to accept the employer's outlook and represent it in convincing fashion. The shop steward cannot be regarded as the best means of propagating information which the employer believes the individual worker ought to know. It is suggested, therefore, that the institution of the factory journal or house organ should be much more extensively developed, either for the individual factory or a group of factories, and that in its columns should take place from time to time a full consideration of the various domestic problems which constantly arise. A wise works' director, who could have a weekly talk with the bulk of his employees through such channels, would achieve a work, the importance of which could not be measured.

Some attempt, too, must be made to demonstrate to the public at large the governing factors on economic questions. It has not been realised, for instance, that the tremendous increase in the price of labour and raw material, is making it impossible for the country to finance the volume of output of which it is capable, with a consequent reduction in the purchasing power of the nation. It is not understood that every increase now made is simply making the evil more pronounced, and defeating the very purpose for which it was designed. Subsidised houses, transport, coal and other commodities have been accepted with the utmost complacency, and a feeling has been created that such political strategies can be substituted for work. There has been no real insistence on the fact that the primary duty at the moment is to produce in the utmost quantity at the cheapest rate, and that instead of the studied indifference experienced, the whole of the community should be mobilised to this end.

The time has come, too, when the mischievous interference by Government Departments in industrial negotiation should be considerably curtailed. It cannot be eliminated, because the Government is responsible for the maintenance of law and order in the realm: it is the custodian of the interests of those not directly affected by a dispute, and, as such, is an interested party whose voice when necessary must be heard. But it has been proved on many occasions that a Government is too susceptible to outside considerations. Expediency is the only recognisable note of its industrial policy. And where it is quite well known that one party to a discussion will always give way to expediency, the other may well be expected to remain obdurate. The workers are clearly entitled to receive from industry the greatest advantage which industry can afford, but this line cannot be overstepped without grave menace to themselves. There comes a time, therefore, when necessity must govern, and this point can best be determined by the directional heads of industry on the one side and the trade unions on the other.

Finally, our industrial and social difficulties can be eased by the efficiency of the employer. He it is who in a very real sense has to keep running the wheels of industry, and on him depends to no small extent the economic security of the country. But has the inanimate side of production been reduced to the science it might become, or is industry still instinct with the conservatism of old-established practice? Is the art of production studied or does it simply evolve? Much time and money could be saved if the lessons of experience were anticipated or even supplemented by the training of the schools.

It is advisable that employers should cultivate more the practice of the open door. They should develop a community of interest, interchange ideas, treat each other not as competitors but coadjutors. No individual is strong enough to withstand the tendencies of the times, and these certainly call for unity of purpose, knowledge and action. The hope of the future lies in the possibility that capital and labour may develop a better understanding and encourage a mutual inclination to further each other's reasonable aspirations. Such an end would have magnificent results, but it will not be attained until the nation consciously strives to bring it about.

* Paper read before the Institution of Mechanical Engineers, at Lincoln, July, 1920.

ELECTROCULTURE.—Whilst the experiments conducted by Sutton and Sons, of Reading, on the electrification of seeds by the Wolfryn process cannot be considered as encouraging, the experiments made by Heim in the Conservatoire des Arts et Métiers at Boulogne-sur-Seine on electroculture by brush discharge certainly look promising. Heim used, from July to October, 1919, currents of about 20,000 volts coming from a Gaiffe transformer. He buried the negative pole, an iron plate 1 m. square, 1·50m. in to the soil, and suspended thin iron wires, 0·5 mm. in diameter, 2 m. above the soil, about 0·8 m. apart, from bell insulators of varnished glass. When the electrodes are so unequal in size, the current flows only in one direction, without needing any rectifiers. The electric radiation was applied every day twice, about 6 a.m. and 6 p.m., for periods of 1½ hours or 2 hours. On hot clear days the morning electrification was suppressed in favour of the evening treatment. All the plants were already fairly advanced when the treatment began. Tobacco plants grew to a height of 1·2 m. (instead of 0·5 m. on control plots) and blossomed in September, whilst the other plants did not blossom at all; cabbages improved, potatoes and sugar beetroot, &c., increased by 25 per cent. in yield and by 4 per cent. in starch and by 20 per cent. in sugar, and there were other good results. In the Wolfryn process the seeds are immersed in an aqueous solution of common salt or calcium chloride, through which the current is passed; the seeds are then dried at 100 deg. F., and are ready for sowing. The experiments described in Bulletin No. 11 of Messrs. Sutton were to establish whether the immersion or the electrification, or both the agents combined were advantageous; mangolds did improve; in all the other cases the advantages were either negligible or more than doubtful.

THE CONCRETE INSTITUTE.—By the consent of Mr. C. R. S. Kirkpatrick, chief engineer of the Port of London Authority, a small party representing the Concrete Institute visited the new river jetty at Tilbury on Tuesday, June 22. The work consists of a main jetty 1,000 ft. long, by 50 ft. wide, parallel to the shore, and a curved viaduct 900 ft. long, carrying the railways from the main jetty to the shore, where they are connected up through the dock lines with the general railway system of the country. The main jetty is a double-decked structure, the space between the two decks forming a transit shed. The lower deck is about 6 ft. above high water-level. Access to the transit shed is provided by hatchways through the upper deck. The whole of this structure is carried on cylinders sunk generally 2 ft. into the ballast which occurs about 40 ft. below ordnance datum. Clusters of piles are driven in the cylinders, which are then filled up with concrete. Electric cranes of 60-ft. radius to lift 2 tons, are provided on the river side of the jetty for handling the cargoes of ships; cranes of 40-ft. radius are provided on the landward side of the jetty to deal with the loading of barges, for which accommodation is provided at the back of the jetty. There are two lines of rails with cross-over roads on the upper deck. The main feature of the approach viaduct is a reinforced concrete bowstring bridge; this is necessary to provide access for barges to the back of the jetty. As the bridge (whose span is 100 ft.) is on the skew, the bowstrings are staggered. Each bowstring weighs about 150 tons. There are over 18 tons of reinforcing steel in each bowstring. The deadweight of decking carried by each girder is about a further 150 tons. Part of the viaduct is built on cylinders in the same manner as the main jetty, but as the shore is approached, the construction is changed to piles. The reinforced concrete dock gates erected a short time since at the docks proved also to be a work of much interest.

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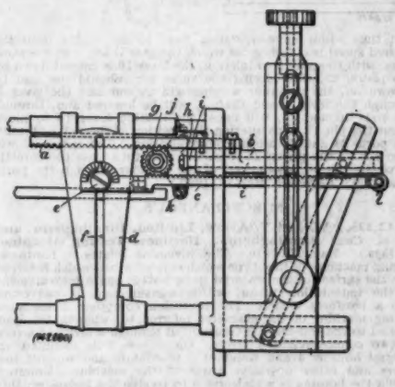
ELECTRICAL APPARATUS.

142,680. Igranic Electric Company, Limited, London, and S. R. Wright, Bedford. Coil-Winding Machines. (2 *Figs.*) May 29, 1919.—The invention relates to coil-winding machines, and in particular to the mechanism for imparting a reciprocating motion to the wire or cotton guide member or members. According to the invention, a pair of toothed racks of equal pitch are provided, one of which is fixed whilst the other is slidably mounted in parallel-spaced relation thereto at a distance equal to the diameter of the pitch circle of a correspondingly toothed pinion. This pinion is revolubly mounted upon the extremity of one of the reciprocating rods by means of which it is caused to traverse the teeth of the fixed rack, simultaneous engagement being also maintained with the teeth of the slidable rack. This latter rack is connected to a guide member. The fixed rack *a* is secured to the rod slide *b*, whilst the slidable rack *c* is disposed in spaced relation to the same, and is connected to the traversing guide member *d* by means of a pin *e* on the forward extremity of the rack engaging a slot *f* in the guide member. A loose pinion *g* meshes simultaneously with both



racks, which pinion is carried by a bracket A mounted upon the forward extremity of the reciprocating rod *i*. The bracket A also carries a pair of rollers *j* and *k*, the lower roller *k* of which serves to support the slidable rack *c* by engaging the underside of the same. Additional support for this rack *c* is provided by a roller *l* which is mounted upon the rear extremity of such rack and engages the underside of the operating rod slide or bearing *b*, thus keeping the rack in alignment with the pinion *g*. The remaining roller *j* rides upon the upper surface of the fixed rack *a*, and thus serves to support the rod *i* and prevent sagging when such rod is fully extended. The two rollers *j* and *k* are in adjustable relation one to the other, and also in relation to the pinion *g*. By this arrangement wear on the racks and pinion can be taken up thereby eliminating "back-lash." In operation the reciprocation of the rod *i* is imparted to the pinion *g*, and since the teeth of this pinion mesh with those of the two racks, the rectilinear motion of the pinion causes it to revolve and impart a rectilinear motion to the sliding rack. This latter motion is compounded of the rectilinear motion of the pinion, and that due to its revolution. (*Accepted May* 19, 1920.)

142,681. Igranic Electric Company, Limited, London, and S. R. Wright, Bedford. Insulation of High-Tension Coils. (3 *Figs.*) May 29, 1919.—The invention relates to high-tension coils in which a high insulation is disposed between consecutive layers of conducting material at the end of each layer where occurs the maximum difference of potential. The invention consists in the winding of high-tension coils of this character, of an insulation strip, adapted to be disposed between consecutive layers of conducting material, which is of tapering width and of such a shape that when applied to the coil the thickness of the

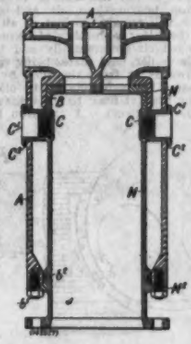
Fig. 1.

Fig. 2.

insulation increases from one end of the coil to the other, which is the end where occurs the maximum difference of potential. This is effected by cutting the strips of insulation *a*, before application, to the required length, and then diminishing the width from a maximum at one end *c*, which corresponds substantially to the width of the coil, to a minimum at the other in such a manner that one long edge *d* is at right angles to the edge *c* of the maximum width. The length of the side *d* of the strip *a* is predetermined from the number of convolutions of insulating material it is required to put between consecutive years of wire. The respective sides *d* of alternate insulating strips are disposed at opposite ends of the core. (*Accepted May* 19, 1920.)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

142,627. W. Hall, London, and R. Wellesley, Goodmayes. Cylinders. (1 *Fig.*) November 3, 1919.—The invention relates to the construction of water cooled internal-combustion engine cylinders of the type in which a separately cast jacket containing the valve ports is detachably secured to a steel liner or barrel of the type which is closed at the head end to contain the valve seatings. According to the invention, an engine having a cylinder casting with the valve ports integral, and provided at its outer end with an opening bored to receive a steel liner, is provided with a steel liner having an external flange formed thereon at or near its outer end, the said flange being provided with a multiplicity of bolts, studs or other means for drawing the liner into position in the casting so that its inner end will be forced into a recess bored in the head of the casting. A in the casting constituting the water jacket with the valve ports integral, M is a



steel liner closed at the head end and provided at the other with an external flange M^2 adapted to be secured to the end of the casting A by studs b^1. A packing ring of rubber b^2 contained in a taper sided groove formed in the liner M enables a watertight joint to be obtained at the lower end. At the head or closed end of the liner the joint is a metal to metal one, the head of the liner being either forced into the recess B in the casting A or placed therein after the casting has been expanded by heat thus relying on contraction to maintain tightness. The differential expansion between the head of the liner and the direct water-cooled walls of the enveloping casting is sufficient to maintain a watertight joint. *C* are the nipples screwed in the liner for the reception of the sparking plugs, and C^1 the ferrules making a watertight joint between the nipples *C* and the wall of the jacket casting A. Between the flange of the ferrules C^1 and the outside of the jacket compressible washers C^2 are interposed. (*Accepted May* 19, 1920.)

142,727. J. Wooler, Alperton. Induction Tubes. (3 *Figs.*) September 4, 1919.—The invention relates to the induction tubes of internal-combustion engines, and is especially applicable to engines having horizontally-opposed twin cylinders. The invention is applicable to engines having induction tubes formed in substantially Y or V-shaped passages in the crank-cases or in an attachment thereto, and in which the carburettor is connected to the foot of the Y or the apex of the V, and the arms or passages therefrom are preferably curved and directed outwardly one towards each cylinder. According to the invention glands are fitted to connect the tubes to the heads of the cylinders and these glands are so formed and constructed that the tubes are capable of some movement in relation to each other, mainly for the purpose

Fig. 1.

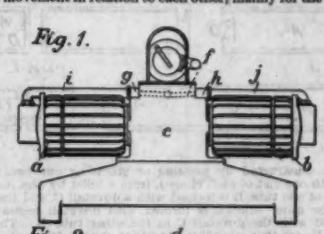
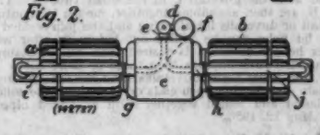


Fig. 2.



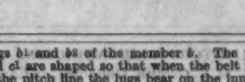
of allowing for contraction and expansion of the tubes. The cylinders *a*, *b*, are of usual type, and between them is the crank-case *c*. The carburettor *d* is mounted at one side of the crank-case and is connected thereto by a short flanged tube *e*. This tube connects to the Y-shaped passage *f* in the crank-case and the ends of this passage are connected to glands *g* and *h* respectively. Tube *i* is fitted into the gland *g* and is connected to the head of cylinder *a* and tube *j* is in like manner connected to the other cylinder. The tube *e* has a downward inclination from the carburettor. The mixture from the carburettor passes equally through the passage cored in the crank-case and therein warmed to a perfect degree for combustion, and one which will eliminate freezing. (*Accepted May* 19, 1920.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

142,663. J. S. McPherson, Belfast. Belt Fasteners. (3 *Figs.*) May 12, 1919.—The invention relates to belt fasteners for driving belts such as are used for effecting the drive in a motor bicycle, or for use in connection with driving belts of a like kind thereto and which have to pass ground pulleys of substantially different diameters. The fastening device for the belt *a* comprises two members *b* and *c*, each of which is secured to an end of the belt *a*. The members *b* and *c* are turnably connected by a transverse pivot pin *d*. The end of the member *b* which connects with the pivot pin *d* has two projections or lugs b^1 and b^2, and the end of the member *c*, which also connects with the pivot pin *d*, has a projection or lug c^1 adapted to fit between the projections or lugs b^1 and b^2 of the member *b*. The projections or lugs b^1, b^2 and c^1 are shaped so that when the belt fastener tends to get below the pitch line the lugs bear on the inner surfaces of the members *b* and *c* and limit the inwards turning movement of the parts of the fastener about the pivot pin *d*, thereby pre-

Fig. 1.

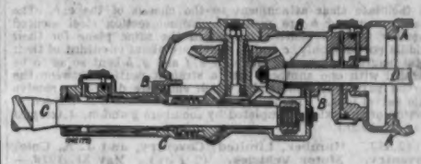
Fig. 2.



venting movements of the ends of the belt below the pitch line. The end of the belt secured to the fastener member *c* is bent into shape before it reaches the pulley *e*, thereby ensuring a better contact therewith. The fastener is secured to the ends of the belt *a* by bolts *f*. (*Accepted May* 19, 1920.)

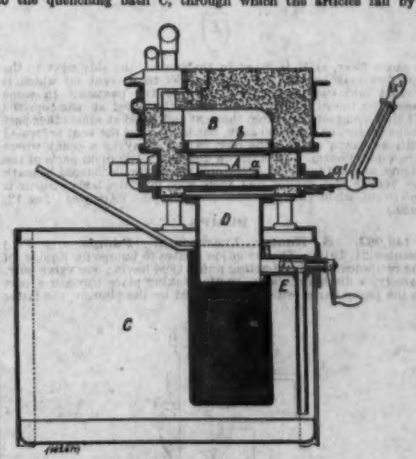
MINING, METALLURGY AND METAL WORKING.

142,172. Mavor and Coulson, Limited, Glasgow, and M. S. Moore, Glasgow. Coal-Cutting Machines. (4 *Figs.*) January 25, 1919.—The invention refers to coal-cutting machines. According to the invention, a body structure is adopted containing a motor and having a head casing suitable for both types of machines, i.e., chain cutter or cutter-bar machines, and for alternative association therewith a cutter-bar head mechanism and a cutter chain head mechanism with auxiliary parts, as may be required, are provided. A designates a portion of the front end of a body structure, in which the motor is contained, having a head casing B, which are embodied in the construction of both



machines. C designates generally the cutter bar-head mechanism. In effecting a conversion to a chain cutter machine, the driving shaft D provided for the cutter bar machine is removed, and replaced by a driving shaft of the cutter chain machine. These shafts may be of the same diameter, in which case the same bearings may be used, or the shafts and bearings may be of different diameters. The driving shaft may be co-axial with and arranged to extend through or partly through the rotor of the motor, and so formed that when introduced a driving connection is established, provision being made for preventing endwise displacement. (*Accepted May* 12, 1920.)

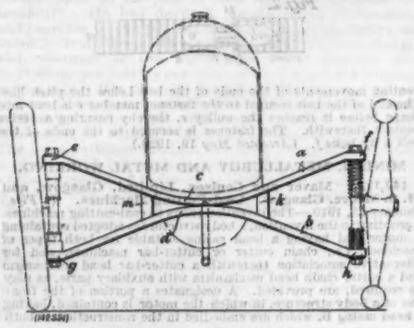
142,671. H. J. Yates, Birmingham, S. N. Brayshaw, Manchester, and E. R. Brayshaw, Manchester. Furnace. (2 *Figs.*) *May* 21, 1919.—The invention relates to furnaces for the heat treatment of metal articles in which the articles are heated in a non-oxydising atmosphere in an externally-heated chamber closed at the entrance and opening into a cooling bath into which the articles are withdrawn without contact with the air. The furnace is constructed with a heating chamber A for the articles to be hardened or tempered and a combustion chamber B separated by a plate *b* from the heating chamber. The heating chamber A is fitted with a movable hearth *a* swivelling on pivots, upon which the articles are laid and from which they can be tipped when heated to the desired temperature. The combustion chamber is heated by gas. The burners may enter the combustion chamber either at the top or at the side and may be straight or L-shaped. The quenching bath C is placed below the hearth *a* of the furnace with a shoot D leading from the heating chamber to the quenching bath C, through which the articles fall by



gravity from the heating chamber to the bath. The end of the shoot D dips into the liquor in the quenching bath, the top of the bath, except the part covered by the shoot, being open to the air. A pipe for the supply of the coal gas is fitted to the shoot D, and the gas enters the shoot and passes from there up into the heating chamber. The articles are maintained in the coal-gas atmosphere until they enter the quenching liquor. A removable cage is attached to the shoot D to receive the articles as they are discharged from the heating chamber A. The roof of the heating chamber forms the floor of the combustion chamber B and is constructed of a plate *b* of steel of suitable composition or other suitable material through which the heat radiates. Apertures may be made in the roof *b* of the heating chamber A, through which some of the coal gas supplied thereto may enter the combustion chamber B. The hearth *a* is mounted on a spindle or shaft a^1 passing to the outside with a hand lever a^2, by which it is operated. A screw E or pump is connected with the quenching bath C to maintain the liquor therein in circulation. (*Accepted May* 19, 1920.)

MOTOR ROAD VEHICLES.

142,331. G. M. L. Griffith, Guildford, and Andre Griffith and Charnock, Limited, Guildford. Steering Axles. (1 *Fig.*) May 31, 1919.—The invention relates to steering axles of cars. A steering axle made in accordance with the invention comprises two curved members secured together in the same plane. The members meet at their centres and separate towards their ends, and may be provided with cross members on either side of their centres for the purpose of completing the double triangular construction of the centre portion of the frame and



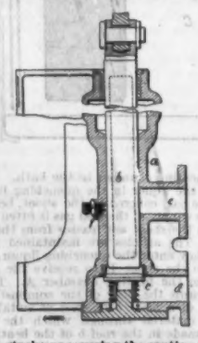
to facilitate their attachment to the chassis of the car. The members *a* and *b* are made of channel section steel secured together at their centres, curved in the same plane for their middle portions only, *c* and *d*, which are about one-third of their total length, and having the ends *e*, *f* and *g*, *h* bent so as to be parallel with one another, with a straight portion between the curved parts and bent ends, which ends are drilled to receive axle swivel pins. The double triangular formation of the centre portion of the axle is completed by members *k* and *m*. (*Accepted May* 12, 1920.)

142,332. Humber, Limited, Coventry, and J. A. Cole, Coventry. Motor Vehicles. (2 *Figs.*) May 31, 1919.—The invention relates to crank-case vents and oil fillers for the engines of motor vehicles. The timing case cover A is cast with a vertical funnel B provided with a cap C. In one side of this funnel is an aperture B¹ communicating with a passage D cored out of the cover casting and leading down to the lower edge thereof. At the end of this passage is fitted a pipe E having a bevelled end, the mouth of which projects backwards as regards the direction of motion of the vehicle. It will be clear that any oily vapour passing up the funnel, will travel down the passage and out of the pipe without dirtying any parts of the engine. If

a gauze filter, as F, is fitted in the funnel, the side next to the aperture may be blanked off as at F¹ to prevent oil which is poured into the funnel from entering the passage. In some cases, the funnel B may be permanently closed at the top, the oil filler being separate from the vent and fitted at some other part of the engine, or to the oil tank, but in all cases the vent is formed with a branch leading the oily vapour away to a point where it can do no harm. Thus the oil does not settle upon parts of the engine, and the fumes from the crank-case are discharged beneath the vehicle and cannot find their way into the body, which is important when this is of the closed type. (*Accepted May* 12, 1920.)

PUMPS.

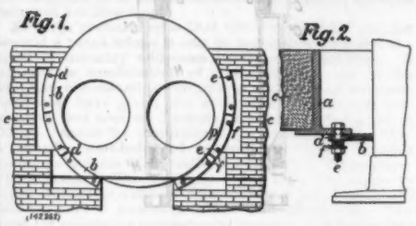
140,982. S. Hunter, Tynemouth. Pumps. (1 *Fig.*) October 21, 1919.—The invention relates to pumps for liquids of the reciprocating single-acting pump type having one valve only, namely, a discharge valve, suction taking place through a port in the pump barrel which is controlled by the plunger, the latter



during its suction stroke uncovering the suction port. *a* designates the pump barrel and *b* the plunger. The barrel has at its lower end a spring-loaded discharge valve *c* adapted to discharge through a discharge port *d* during the downstroke of the plunger. *e* designates the suction port provided in the barrel and adapted to be controlled by the plunger *b*, said port being normally covered by the plunger, but so disposed as to be uncovered by the plunger towards the end of the suction stroke. During the return stroke the plunger covers the port again and discharges through the discharge valve *c*. The pump is provided with an additional port *f* which is connected by a pipe to the bottom of the condenser or air pump suction pipe or other position where a lower pressure exists and serves to provide equalisation of pressure, said port *f* being also uncovered towards the end of the suction stroke of the pump. Thus in the event of the pump failing to function properly, *i.e.*, failing to produce a sufficient suction to deal with the liquid conducted to the suction port, the necessary additional suction is produced by the uncovering of the port *f* communicating with a part at which the pressure is less than that obtaining in the vessel connected to the suction port of the pump. (*Accepted April* 14, 1920.)

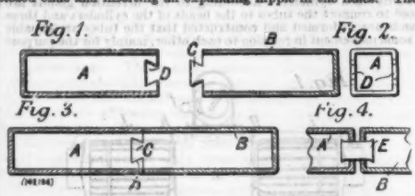
STEAM ENGINES, PRODUCERS, HOLDERS, &c.

142,262. E. Warrington, Hyde. (2 *Figs.*) **Steam Boilers.** April 4, 1919.—This invention relates to boilers, and particularly to boilers of the Lancashire, Yorkshire or Cornish type. The invention provides an air and gastight circumferential joint which will remain efficient at all times. It comprises at each side the latter a plurality of segmental plates with curved edges arranged circumferentially end to end with the flues and against the boiler, said plates being capable of adjustment separately towards or from the shell by means of bolts carrying springs passed through slots in the plates and through holes in a supporting bracket fixed to the brickwork. The bolts may be built in the brickwork. A cast-iron frame *a* is built



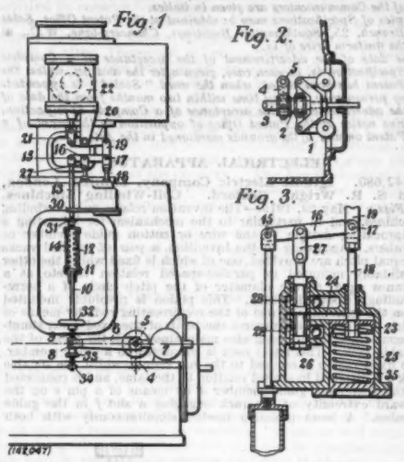
into and supported by the usual brickwork *c*. Supported by and attached to the frame are three or more metal segmental plates *b*. The said plates have slots *d* cut or formed in them through which passes the supporting and securing bolts *e*. By reason of the slots *d*, adjustment of the plates *b* to or from the axis of the boiler to effect close contact with the shell of the latter is secured. To provide for the movement of the boiler during expansion and contraction a spring washer *f* is employed in combination with each holding or securing bolt *e*. Sufficient play is permitted to admit of circumferential and radial movement when necessary, at the same time the plates are securely held against the boiler shell to provide an air and gastight joint. (*Accepted May* 12, 1920.)

142,186. E. Green and Son, Limited, Wakefield, and G. E. Tansley, Wakefield. Boiler and Economiser Headers. (6 *Figs.*) January 29, 1919.—The invention relates to headers for boilers, fuel economisers and other vessels for containing fluids at high pressures and consists in forming the headers by pressing or stamping out two tubes with one end of each closed from a billet, and joining the open ends of such tubes together by welding, and where a larger header or vessel is desired, then one or more open-ended tubes can be joined in between the tubes having one end closed, also two or more of these headers can be joined together end on by drilling and boring the adjacent closed ends and inserting an expanding nipple in the holes. The



header is constructed by pressing or stamping out two tubes, A, B, (with one end of each closed), from a billet by dies, and the open end of one tube B is formed with a dovetail C, and the open end of the other tube A is formed with dovetail recess D to correspond with the dovetail C in the other tube B. The two tubes A, B, are then assembled together, mouth to mouth, with the dovetail or dovetails interlocking and the join welded. The tube and lid holes can be drilled out before or after welding. If a larger header or vessel is desired than can be stamped or pressed out in two stampings then three or more tubes can be employed, the tubes being dovetailed and welded together, the intermediate ones having open ends or, if desired, the solid ends may be bored and joined together with expanded nipples E. (*Accepted May* 12, 1920.)

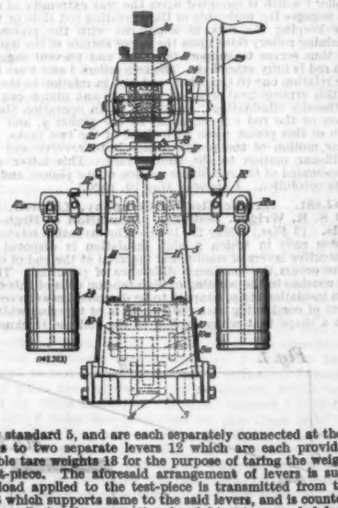
142,047. W. Walker, Bolton. Speed-Controlling Gear. (3 *Figs.*) November 20, 1919.—The invention relates to speed-controlling gear for steam, gas and like engines, of the kind in which the throttle valve, through which the operating fluid is admitted to the engine, is controlled by a piston moving in a cylinder under the action of a fluid admitted through a valve which is controlled by the governor. 1 is a spring-loaded crank-shaft governor connected to a sleeve 2 which slides on the shaft 3. A forked lever 4 is keyed to a cross-shaft 5, and is coupled to the sleeve 2 by clips and set pins. Keyed also to the shaft 5 is a lever 6, which has a weight 7 at one end to balance the other parts of the gear, and at the other end is forked to receive a swivelling block 8. This block is tapped to receive the screwed portion 9 of a rod 10, said rod having an enlarged end 11, which moves within a casing 12, to which is attached the rod 13. A spring 14, within the casing, bears on the part 11 and the end of the casing. The rod 13 is, at its upper end, connected by a pin 15 to one end of a floating lever 16 which, at its other end, is connected by a pin 17 to the piston rod 18 of the piston 23, and to a link 19. The link 19 is connected by a pin to one end of the lever 20, which, at the other end, is connected by a link 21 to the throttle valve 22 of the engine. The piston 23 moves in a cylinder 25 having a slide valve 26 controlling the supply of actuating fluid thereto. The slide valve 26 is connected by a link 27 to the floating lever 16. The slide-valve ports are indicated at 28 and 29, and the cylinder port at 24. A projection 30 is cast on the flange of the cylinder of such length that it is in the path of movement of an adjustable collar 31 on the rod 13. A hand wheel 32 is fixed on the rod 10. A locking wheel 33 is provided to lock the gear so that the engine operates at any desired speed, and an adjustable collar at 34 to limit the movement of the lever 6 in one direction, the hand wheel 32 limiting it in the other direction. A spring 35 is arranged within the cylinder 25 under the piston 23. The operation of the apparatus is as follows: The throttle valve 22 is given a slight initial opening to start the engine. The slide valve 26 is then in its highest position as shown in Fig. 3, and actuating fluid, for example, oil, will be admitted to the top of the piston 23 through the ports 28 and 24, thus forcing the piston down and causing the throttle valve 22 to operate through the links 19 and 21 and the lever 20,



and thus admit more operating fluid to the engine until the desired speed is obtained for which the gear is set. At the same time, with the pin 15 as fulcrum, the lever 16 is carried down by the piston 23, thus closing the valve 26. Should the load be thrown off, the governor weights will fly out and the lever 6, through the lever 4 and shaft 5, will be lowered and, through the rods 10 and 13, will cause the floating lever 16 to move about the pin 17, thus altering the position of the valve 26 until the ports 24 and 29 are in communication. The spring 35 will then act on the piston 23 to raise it and thus close the throttle valve 22, the oil passing out of the cylinder through the ports 24 and 29. (*Accepted May* 12, 1920.)

MISCELLANEOUS.

142,323. W. and T. Avery, Limited, Birmingham, and H. N. Cox, Birmingham. Hardness-Testing Machine. (2 *Figs.*) May 27, 1919.—The invention relates to hardness-testing machines of that type which employ a ball which is forced into the surface of the material to be tested, and a measurement of the indentation taken, which measurement is converted into a hardness record. The invention comprises a hardness testing machine of the character referred to, wherein the load applied to the test-piece is transmitted through a series of levers to two counterweighted levers. On a base 3 is mounted an integral housing 4 and standard 5 to contain and support the levers and other operative parts of the machine. Mounted within the housing is a platform 6 to receive the test-piece, this platform is supported by means of legs upon the knife-edge 8a of a lever 8, of a double bar formation, located within the housing, this lever 8 is connected by a link to a second lever 10 of double bar formation which, in turn, is connected by a common knife-edge 10a to two connecting rods 11, which pass upward through



the hollow standard 5, and are each separately connected at their upper ends to two separate levers 12 which are each provided with slidable tare weights 18 for the purpose of taring the weight of the test-piece. The aforesaid arrangement of levers is such that any load applied to the test-piece is transmitted from the platform 6 which supports same to the said levers, and is counter-balanced equally by the proportional weights 14 suspended from the knife-edges 12a of the levers 12. The ball 15 by which the indentation is made in the specimen is carried on the lower end of a quick-threaded screw 16, the said screw having an adjusting wheel 17 mounted thereon which can be locked in the screw by means of a pin 18. This screw has bearings 19 in the overhanging part of the standard 5, and has mounted thereon a wormwheel 20, which meshes with a worm 21, mounted on a spindle 22 disposed at right angles to the screwed spindle 16, the worm spindle 22 being provided with a wheel 23 for imparting rotation to the said spindles, whereby the ball 15 is forced into the test-piece until the duplex counterbalanced levers 12 are raised. The screwed spindle 16 is provided with a ball race so as to reduce friction. (*Accepted May* 12, 1920.)